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Finds Chemicals That Render Cancer Virus Harmless. Another advance has been made toward the solution of the cancer problem.

Dr. Margaret R. Lewis, of the department of embryology of the Carnegie Institution of Washington, and Dr. Howard B. Andervont, of the Johns Hopkins University, have just succeeded in establishing that the unidentified organism that causes the Rous chicken sarcoma can be rendered inactive by means of small quantities of aluminum and calcium salts.

The significance of this work lies in its possible application in the treatment of human cancer. An immense amount of research will have to be done before any such result is likely to ensue but these recently learned facts point the way to a new direction for cancer research in other laboratories. The chemicals that have been used in the treatment of cancer in the past have been highly toxic in character with a strong tendency to injure other parts of the body as well as the cancer cells. If it is found that calcium and aluminum compounds, either given by mouth or injected into the blood stream, will have an adverse effect on cancer in chickens, it may lead to results of great benefit in treating human cancer because these compounds are more or less inert with little capacity to harm body tissues.

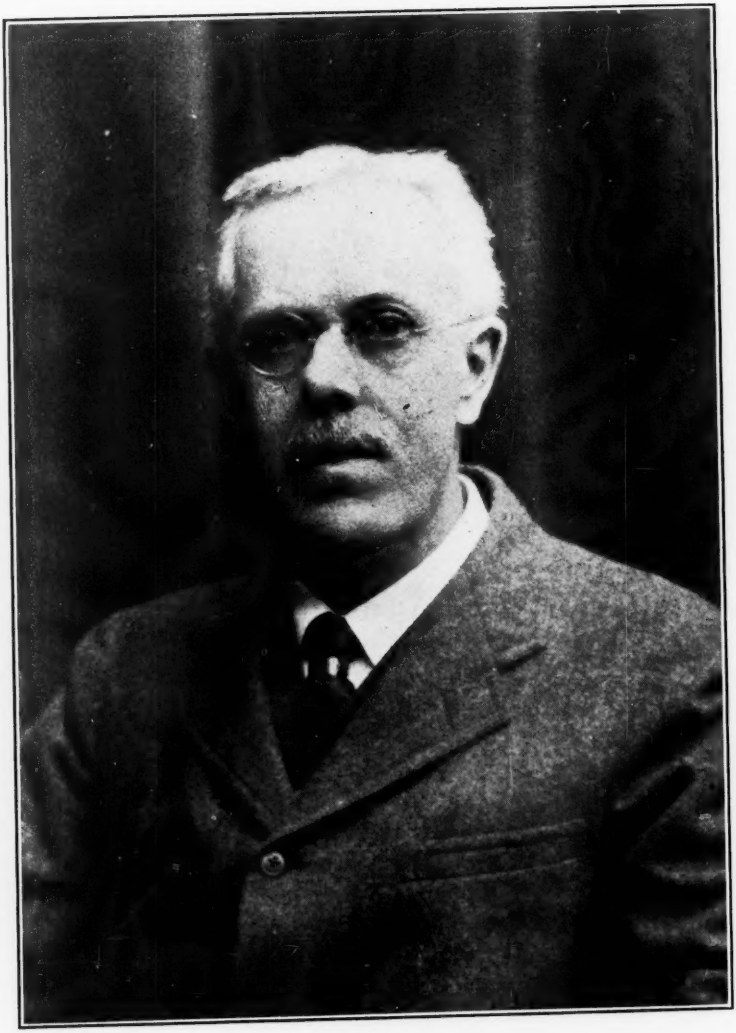
"While the primary tumor of this particular type of malignant chicken cancer," explained Mrs. Lewis, "differs in some respects from those found in human beings and higher animals, the secondary tumors or metasteses, as they are called, are similar to the malignant sarcoma of man. The chicken tumor behaves quite as those of other kinds of animals in that it invades the tissues, develops metasteses, leads to the death of the animal, and can be transferred by means of transplantation from one animal to another of the same species, though not, of course, to an animal of a different species.

"The chicken tumor also resembles certain other diseases in that it is caused by a still unidentified agent that behaves like the so-called filterable viruses responsible for smallpox, rabies, and encephalitis in rabbits. Many years ago Dr. Peyton Rous and Dr. J. B. Murphy of the Rockefeller Institute for Medical Research found that the causative agent of chicken tumor remained active in a filtrate of glycerine extract or in the dried material of the tumor itself. It was also established by these workers that inoculation of these agents not only produced the disease but if the animal recovered from the tumor it was more or less immune to further inoculation of the tumor virus."—*Science Service*

Bacteria in Milk Destroys Botulism Poison. Milk has never been tracked down as the guilty source of a case of botulism poisoning because two types of bacteria commonly present in it have been found to have the power to destroy the toxin produced by the botulinus organism.

This conclusion is the result of experiments conducted in the laboratories of Cornell University and reported to the Society of American Bacteriologists recently, by Dr. J. M. Sherman, C. N. Stark, and Pauline W. Stark. Cheese is also protected from the deadly botulinus germ because one type of the beneficient bacteria is present during the early stages of ripening in most cheeses, while the other is one of the predominating organisms in all types of cheese during the later stages of ripening.

Studies on the heat resistance of bacteria in milk were reported by Dr. A. H. Robertson of the Vermont Agricultural Experiment Station at Burlington. Most efficient pasteurization of milk can be secured if the heat is applied before the microorganisms have passed the accelerative growth stage, the bacteriologist declared.—*Science Service*



DR. E. M. CHAMOT

EDITOR'S OUTLOOK

FEW men are qualified to speak so authoritatively concerning instruction in chemical microscopy as Dr. Chamot who, with Dr. C. W. Mason, writes on that subject in this number. Dr. Chamot's interest in the microscope as a chemical tool dates back to his student days, for we learn that his thesis for the B.Sc. Chem. degree was illustrated by the use of a home-made photographic apparatus which he himself had contrived. He was already assisting in quantitative analysis during his senior year at Cornell and was given the rank of instructor in that subject when he began to prepare for the doctorate which he received six years later.

Dr. E. M. Chamot

During that time he had consistently experimented with all the published microscopic methods and tests which he could discover, using a microscope purchased out of his own funds, for the department then owned none. From time to time, as he could afford to, he acquired additional equipment. Upon the receipt of his doctorate he packed up his precious microscope and betook himself to Europe to seek new viewpoints and to learn more of microscopy under the men who were then doing work in that field. Most of his time was spent in studying methods and in asking questions, for no formal courses in the subject were offered. In this manner he visited the University of Nancy, the Polytechnicum at Delft, the Technische Hochschule at Braunschweig, and the Pasteur Institute of the University of Paris. The microscope which accompanied him is the one which he still uses today.

After his return to Cornell, Dr. Chamot was eventually permitted to offer a course in microchemical analysis. His superiors, no doubt somewhat dubious at the outset, soon became enthusiastically convinced of the possibilities of his subject and he was requested to offer a course in chemical microscopy which would be required of all students specializing in chemistry. His "Elementary Chemical Microscopy," which appeared in 1915 and was revised in 1921, was an outgrowth of that course.

An enumeration of the important consulting positions which Dr. Chamot has held, of the scientific societies to which he belongs, and of the subjects on which he has written papers and books would assume the proportions of a rather extensive catalog. We refer the reader to "American Men of Science" and "Who's Who." We may add, however, that his hobby is nature study and that the sports which find favor in his eyes are small game hunting, fishing, and rifle and pistol shooting.

EVERY now and then at an educational meeting some professor of freshman chemistry makes a remark which is well calculated to

infuriate every high-school teacher present. This remark is variously phrased but its general sense is that the freshman instructor in question would prefer to teach chemistry to students who have never dabbled in the subject in high school. Unfortunately, scholastic records in many cases appear to furnish some justification for this attitude.

Two-Edged Criticism

Why does this state of affairs exist? We do not hear instructors in calculus declaring that they would rather deal with students who have never had algebra nor professors of composition and rhetoric wishing for students with no previous training in English. Have high-school teachers of chemistry a monopoly on incompetence?

Not at all. It is true, in some of the smaller rural high schools, that chemistry is taught by teachers who have never specialized in it and who are forced to teach it as a side-line to the subject in which their interests really lie. But these are not as a rule the teachers who attend chemical education meetings and subscribe to professional journals. There is little to be gained by discussing their case here. After all, the students who pass through their hands are decidedly in the minority.

Wherein, then, does the difficulty arise? Originally, this question might have been partially answered by pointing to the fact that it was generally difficult to determine just what a high-school course in chemistry might mean. The science does not so readily lend itself to segmentation as does mathematics, for instance. Nor is it pedagogically so old or so static as English. The division of labor between high school and college was not obviously indicated either by the nature of the subject or by custom. The only possible division, therefore, had to be arbitrary in nature, and, as each individual instructor set up his own arbitrary standard, the results were naturally confusing. The problem was still further complicated by the fact that the high-school teacher could not devote all his efforts to preparing students for college. The majority of his pupils were getting their *only* course in chemistry.

It was at this point that the average college instructor made his mistake. He refused to puzzle his head over a question that had no answer and decided to treat all freshmen alike. He naively reasoned that those students who had not had chemistry would start at scratch and that those who had would be all the better for a little repetition and review. The unsatisfactory results which followed he explained by saying that courses in high-school chemistry had served only to give students a totally unjustified confidence in their own knowledge, with the consequence that they neglected to study and finally made poor records or actually failed. There was just enough truth in this diagnosis to deceive the college teacher and to disgruntle everyone else. A more illuminating statement of the case would have been to say that the

high-school student of chemistry had his interest in the subject killed early in the college year by a great deal of monotonous and profitless repetition and that the college teacher was never able subsequently to revive that interest.

However, there is no longer a good excuse for evading the issue. The correlation outline prepared and recently revised[1] by the Committee of Chemical Education of the American Chemical Society furnishes a reasonable summary of what may be expected of a high-school course in chemistry. It is frankly arbitrary in the sense that it is necessarily based upon opinion. But it represents the consensus of opinion of experienced and successful teachers in both high schools and colleges. It places no limitations upon the high-school teacher but it does furnish the college teacher with a minimum which he may take for granted. A recent survey[2] indicates that the correlation outline is already being followed in at least fifty per cent of our high schools and no doubt many others are offering courses which fulfil its requirements. Textbook publishers also have displayed a gratifying interest in the correlation idea and a desire to bring their products into accordance with the requirements of the outline.

On the whole, it may be said that sufficient progress has been made not only to justify the universal creation of separate freshman classes for students who have had high-school chemistry, but to render any other course of procedure unjustifiable. Even the student whose high-school preparation has not been all that might be desired will profit by such segregation, for it is preferable to place him upon his mettle and to let him know that he must exert extra effort to remain abreast of his classmates, rather than to bore him with a repetition of much that he already knows and so to allow him to form the habit of resting upon his oars. Hereafter, when freshman instructors proclaim that they obtain better results from students who have never had high-school chemistry, they may well pause to consider whether the implied criticism does not involve themselves as well as the high-school teachers.

Benevolent Taxation

A RECENT news item in *Science* carries with it a hint of interesting possibilities. It is announced that the Wisconsin Alumni Research Foundation has been organized "to promote, encourage, and aid scientific investigation and research at the University of Wisconsin and to assist in providing means and machinery by which scientific discoveries of the faculty, the staff, alumni, and students may be applied and patented." The Research Foundation was organized following the discovery by Professor Harry

[1] See THIS JOURNAL, **4**, 640–56 (May, 1927).

[2] See *Ibid.*, **4**, 911–3 (July, 1927).

Steenbock that antirachitic properties can be imparted by irradiation to foods in which this factor is lacking or deficient in amount. Dr. Steenbock's invention is the first assigned to the Foundation. It is reported that negotiations have been completed whereby the Quaker Oats Company is granted the license to the invention in return for royalties which will eventually amount to $60,000 annually. Since the new Foundation is not a profit-making organization, it is to be inferred that the income derived will be devoted to the prosecution of further researches.

There has long been a feeling, in certain quarters at least, that educational institutions should confine themselves strictly to "pure" research and leave problems involving marketable ideas to be developed by commercial organizations. It is altogether right and proper that we should look to our university laboratories to uphold the torch of "pure" science. With a few notable exceptions they are the sole seekers of truth, without reference to immediate application or personal gain. One could not view, save with regret, any disposition on their part to abandon a task which they have so faithfully and ably discharged in the past. On the other hand, if we may employ so hackneyed an expression, it is entirely possible to maintain an upright attitude without leaning to rearward. A spirit of fidelity to "pure" science need not imply a conviction that some taint attaches to applied research.

It can hardly be denied that some problems of industrial significance may be attacked more effectively in the university laboratory than elsewhere. Furthermore, it frequently happens that purely academic investigations quite unexpectedly develop or suggest commercially valuable ideas. In cases of this kind it has sometimes been considered ethically imperative to dedicate the discovery to the public welfare. One cannot but admire the spirit of altruism which prompts such action, yet one may reasonably question whether the public might not in the long run have benefited to a greater extent if it had been compelled to pay a small tax toward the support of future research. The inventor's royalties are, after all, but a minor item in the cost of a product to the individual purchaser, yet, in the aggregate, they are capable of supporting a rather ambitious program of investigation. No motorist objects to the payment of a reasonable toll to defray the costs of construction of such aids to safe and speedy travel as the Hudson Tunnel or the Camden-Philadelphia bridge. No more should the purchaser of the fruits of applied research object to the collection of a toll to be applied toward making new discoveries possible.

The Wisconsin Alumni Research Foundation is evidence that a very sane view of the ethics of scientific commercialization is beginning to find favor. We trust that it may flourish and take root elsewhere.

CHEMICAL MICROSCOPY. I. CRYSTALLIZATION EXPERIMENTS AS AN INTRODUCTION TO METALLOGRAPHY*

E. M. CHAMOT AND C. W. MASON, CORNELL UNIVERSITY, ITHACA, NEW YORK

Somewhat over a decade ago the senior author became convinced that a series of easily performed and characteristic crystallization experiments would greatly assist students in attaining the knowledge so necessary to an understanding and interpretation of the microscopic appearances of surfaced and etched metals and alloys.

A number of simple experiments were devised with low-melting compounds: compounds that possessed the property of crystallizing well from their melts on cooling. Each student was required to perform the experiments, note and record the phenomena taking place and interpret the appearances of the solidifying compounds in the light of his knowledge of physical chemistry. Since these laboratory practices were completed prior to the examination of metallurgical products, the students looked upon them as chemical experiments, studies upon chemical equilibria, and were thus led to study equilibria diagrams in textbooks on physical chemistry and refresh their memories relative to the phase rule. This induced attitude of mind we found to be especially desirable in our students in engineering who lacked the chemical background and viewpoint of the students who had the advantage of prior instruction in physical chemistry. They found the experiments interesting and enlightening, the phenomena observed fascinating, and they were, therefore, stimulated to visit the library and read, without pressure being brought to bear upon them by the staff of instruction. They thus acquired a deeper interest in physicochemical metamorphosis, a far better comprehension of the phase rule and a realization that chemical theory and chemical phenomena are the bases upon which the science of metallography is founded.

These introductory practices enabled the student to study and follow the progress of the phenomena of "freezing" and thus to comprehend the mechanism of crystallization in metals and alloys. This introduction of chemical microscopy into our course in metallography proved so remarkably successful that as time went on more and more experiments were devised until we were able to duplicate with transparent compounds most of the structures and metamorphoses encountered in the microscopic study of metallurgical products. Of course, this of necessity extended the laboratory periods devoted to introductory practices and to that degree curtailed the time which could be devoted to the actual study of

* This article is respectfully dedicated by the authors to L. M. Dennis. It will be reprinted as Article No. 7 in the Louis Monroe Dennis Quarter-Century Volume, to be published in 1928 in commemoration of the completion by Professor Dennis of twenty-five years of service as head of the department of chemistry at Cornell University.

alloys, but we have found this apparent loss of time to be more than compensated for by the much better grasp, by the students, of the whole subject of alloy structure and alloy behavior, and we have been able to cover more ground and prepare and study a greater number of metallurgical products than before we introduced the preliminary exercises.

During the many years of experience in teaching classes in various branches of chemistry, we have found that, to the average student, freezing points, eutectics, transformation points, enantiotropic and monotropic metamorphoses, etc., appear to mean only a certain type of curve or graph which he has learned and upon seeing or hearing these terms he almost invariably visualizes the particular type of "graph" he has memorized; but of the actual phenomena or the mechanisms of the reactions he can form no mental picture. So, too, he finds it difficult to properly understand "crystal grains," "grain size," "grain boundaries," "crystal orientation," "lines of weakness," etc., structures he must recognize in alloys, for such structures he has never seen before. Crystals separating from solution he is familiar with but crystals forming in a melt are wholly outside his experience.

It appeared logical, therefore, that we should set ourselves the task of trying to find a way of supplying this lack of knowledge in a striking, easily assimilable form. This could be done if we could devise a series of experiments which would illustrate what happens when molten crystallizable substances or mixtures of substances solidify on cooling under varying conditions. Obviously our problem has been to find a series of compounds and mixtures fusing at low temperatures, which upon cooling would form well-defined transparent crystals and which would in proper combinations and under controllable conditions exhibit most of the phenomena to be met with in the solidification of alloys from their melts. Furthermore, transformations must progress slowly enough under the microscope to be readily followed by the eye. There was nothing in the literature to guide us for we were attempting that which was new and novel—even Lehmann's classic "Molekularphysik" and "Das Kristallisations Mikroskop" afforded us little help although a vast fund of knowledge relative to crystallization from fusion is to be found in these remarkable compilations. It was a new field in which we were obliged to proceed slowly and usually by purely empirical experimentation. We feel that it has been well worth while for through these laboratory exercises our students are able to watch and control crystal growth under the microscope and induce and follow physico-chemical metamorphoses in such a way that they cannot fail to understand just what is taking place and they no longer visualize these changes as "graphs" but as actual events.

Most of the phenomena to be described have doubtless been observed by other workers. The physico-chemical reactions have most of them

been described. The writers make no claims for originality save in the selection of the material and in its treatment under the microscope. That which they believe to be new and novel lies in the adaptability of the experiments to throw light upon the structure of alloys, rocks and material produced by fusion, and also to demonstrating some of the many ramifications of the phase rule.

The experiments may be performed by individual students or may be used as demonstrations before an entire class, each member looking into the microscope in turn, and they lend themselves equally well to microscopic projection. No doubt excellent and highly interesting "movies" can be prepared. These the writers intend to attempt.

Only a few of the many possible experiments have been described below, illustrated by photomicrographs in order to make plain what may be accomplished and what we have had in mind in the planning of experiments serving as an introduction to metallography. In these photographs it must be borne in mind that color, texture, motion, and space relations are lost (though readily grasped by the observer looking into the microscope). Even so we believe that these single pictures in black and white speak eloquently of what may be seen and what may be accomplished. In order that the reader may judge how closely these experiments demonstrate the phenomena taking place in alloys, photomicrographs of metal and alloy structures are shown in juxtaposition with the photographs of the crystallizations of the selected chemical compounds.

Setting wholly aside their pedagogic value in collegiate laboratories, these "freezing" experiments are well worth while repeating by every chemist, not only because of their beauty and fascination but because he will gain a far better idea of the fine structure of matter and of physicochemical changes than he had before and will view his phase rule in a different and more useful light.

When a metal is cast, the phenomena of crystal growth may be inferred, but can hardly be observed directly. When a melt of a transparent substance solidifies, these phenomena may be followed *as they take place.* If it is desired to duplicate the casting of an ingot, the material may be fused under a cover glass on a thin slide (or better, between two cover glasses). The molten preparation is cooled by placing on a block of brass which is pierced by a hole 1 cm. square. This serves to abstract heat from the edges of the specimen just as the mold removes heat from the molten metal, and crystal growth proceeds inward towards the center in directions roughly perpendicular to the cooling surfaces.

After the student has watched such a melt solidify (Fig. 1) and has observed the development of lines of juncture bisecting its angles (Fig. 2) he has some concrete evidence as to how similar structures originate in metal ingots (Fig. 3). The need for "fillets" in casting, in order to elimi-

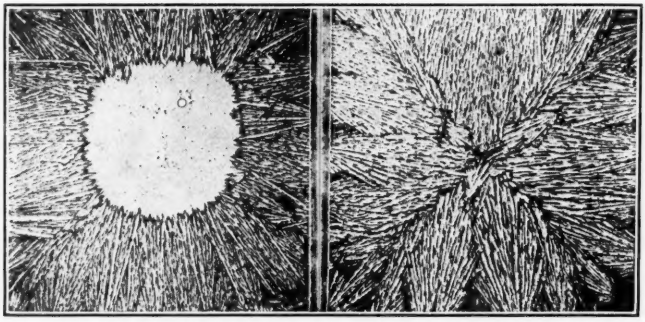


FIG. 1. FIG. 2.

FIG. 1.—SOLIDIFYING MELT OF *o*-NITROPHENOL COOLED AT THE EDGES BY A PERFORATED METAL BLOCK. 5×

FIG. 2.—*o*-NITROPHENOL, COMPLETELY "FROZEN." 5×

nate these diagonal planes of weakness, is much more vividly exemplified than by diagrams such as are common in books on metallography, for the student sees for himself how the structure comes about.

"Chill casting" can be demonstrated by having the block of brass very cold. This results in the formation of a "chilled" outer layer (Fig. 4) analogous to that found in metal cast in a cold, conducting mold. The nature of the chilled zone is evident in Fig. 5, which shows fine-grained

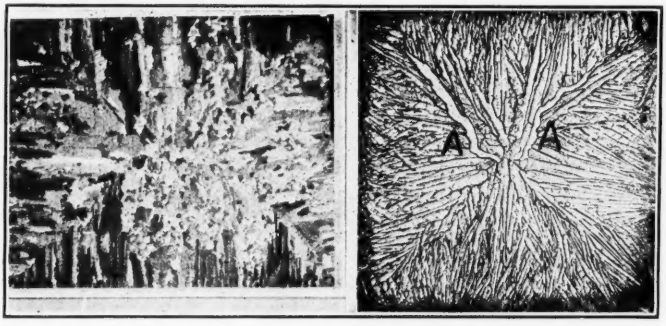


FIG. 3. FIG. 4.

FIG. 3.—ANTIMONY. CROSS SECTION OF INGOT CAST IN RECTANGULAR MOLD. SURFACED AND ETCHED. 5×

FIG. 4.—SULFONAL, "FROZEN" RAPIDLY BY MEANS OF A PERFORATED METAL BLOCK. NOTE THE "CHILLED" ZONE NEXT THE "MOLD" AND SHRINKAGE CAVITIES AT *A*, *A*. 5×

COMPARE DIAGONAL LINES OF JUNCTURE IN FIGS. 2 AND 4 WITH THOSE IN THE INGOT OF ANTIMONY.

crystallization and numerous shrinkage cracks where the cooling was most rapid. Slow cooling, corresponding to casting in a preheated mold, is obtained by placing the preparation on a warmed block of metal. Under these conditions the grain size is greatly coarsened, just as is the case with metals.

Fig. 4 also shows voids (*A*) due to the decrease in volume of melt as it solidified; these may be thought of as analogous to "pipes" or "shrinkage cavities" in metals.

In addition to showing the influence of rate of cooling on the "grain size" of the material, information as to the orientation of its crystals is

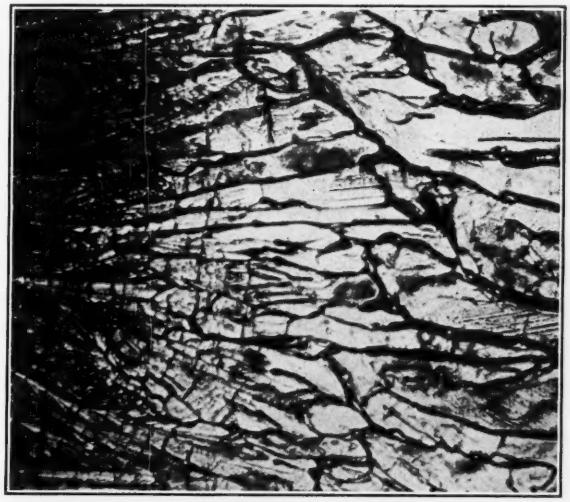


FIG. 5.—DETAIL OF CHILLED ZONE IN FIG. 4. NOTE FINE-GRAINED STRUCTURE AND NUMEROUS SHRINKAGE CRACKS. 50×

also obtainable from the above "micro-castings." In a polished and etched metal specimen such as Fig. 3, the arrangement and size of the crystals is revealed by their "oriented lustre," which causes some to appear light while adjacent ones are dark.

With transparent substances polarized light may be used to give similar information, for when examined between crossed Nicol prisms, the brightness of the crystals depends upon their orientation.

The center of a "cast" preparation of thymol is shown in Fig. 6. The grain appears to be fairly uniformly fine, but examination between crossed Nicols (Fig. 7) reveals many large areas (*A*, *B*) which are really single crystal grains since they extinguish as a unit when the stage of the

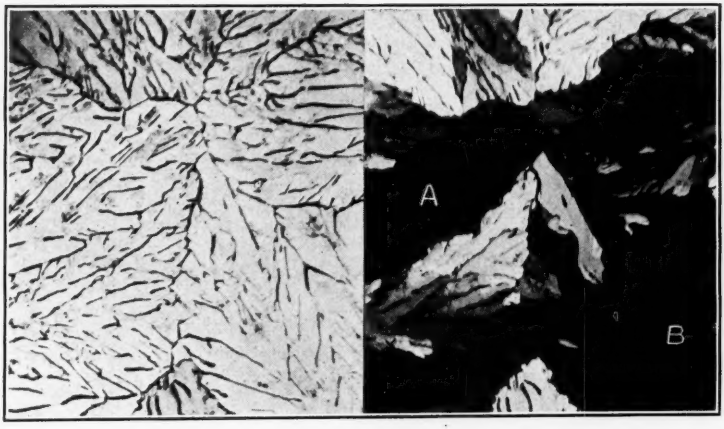


FIG. 6. FIG. 7.

FIG. 6.—THYMOL, SOLIDIFIED FROM THE MELT. ORDINARY LIGHT. 50×

FIG. 7.—SAME FIELD AS FIG. 6, BUT BETWEEN CROSSED NICOLS. NOTE AREAS OF UNIFORM ORIENTATION. 50×

microscope is rotated. It is evident that the lines of inclusions do not necessarily outline individual crystals, and that areas of uniform orientation should constitute the basis of grain size determinations, as is customary in metallographic practice.

Free surfaces of cast metals such as antimony, bismuth, zinc, etc. (Fig. 8) show well-defined dendritic patterns as evidence of their crystalline

FIG. 8. FIG. 9.

FIG. 8.—SURFACE PATTERNS ON CAST BISMUTH. 5×

FIG. 9.—SURFACE PATTERNS FROM SOLIDIFICATION OF UNCOVERED MELT OF THYMOL. 25×

nature, and these have their counterparts in similar patterns formed on the surfaces of melts of transparent materials (Fig. 9) with the advantage that their development may be followed through its various stages. The size and orientation of crystals in metals is of considerable importance, and is commonly studied microscopically.

The more detailed aspects of solidification from the molten state may be studied microscopically by simple melting and freezing of the preparation. This may be repeated many times, and may be controlled, if desired, by a hot stage. It is easy to follow the growing crystals and to observe how an irregular grain boundary develops as the resultant of deposition of material on two adjacent crystal faces. (Fig. 10 *A*.) This helps to explain why polished surfaces of metals do not show the straight lines and angles which we ordinarily expect in crystalline material.

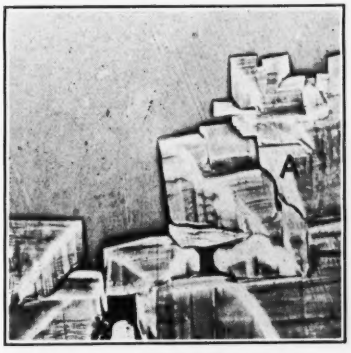


FIG. 10.—CRYSTALS FORMING FROM MELT OF THYMOL. *A*, IRREGULAR BOUNDARY BETWEEN TWO CRYSTALS. 25×

Many of the low-melting substances used in these experiments reject dissolved gases as their melts solidify, just as do metals in the formation of "blow holes." In Fig. 11 such a bubble is being formed and carried along at the angle between two growing crystals.

Crystals also tend to reject any impurities which the melt may contain, and if these are colored they may be seen to concentrate in front of the advancing crystals and at the re-entrant angles between their faces. In Fig. 11, colorless crystals of thymol are separating from a melt which contains the dyestuff Bismarck Brown, and the colored zone of rejected impurity is seen where the developing crystals have refused to take it into their space lattices. This helps one's appreciation of the causes of "coring" in ingots and the concentration of impurities at their centers.

Microscopic observation of melting and solidification also facilitates recognition of an appreciable range of melting points in impure specimens, and is a simple means of demonstrating supercooling.

The phenomena of freezing are familiar to all of us, but this is as far as our ordinary experience goes with one-component systems. Students find it very difficult to visualize the nature of solid transformations, although they may have plotted plenty of curves to prove the existence of more than one solid phase of a given substance. Indeed, very few chemists have ever observed the progress of such a transformation in any direct way.

Under the microscope the growth of one phase at the expense of the other is easily followed and the analogy between *liquid-solid* and *solid-solid* phase changes becomes strikingly evident.

The transformation may be allowed to proceed spontaneously or it may be controlled by regulating the temperature of a hot stage in which the preparation is placed. To take a typical example, ethylamine hydrochloride exists in two solid modifications which are so different in their crystallographic properties that they are easily recognized. Figs. 12 and 13 show successive stages in the growth of the low-temperature modi-

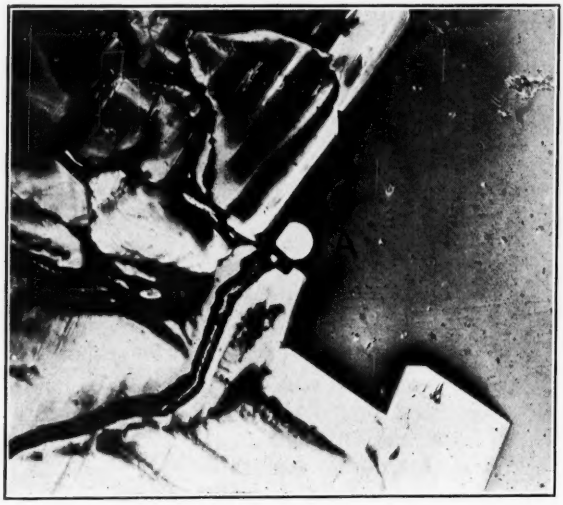


FIG. 11.—REJECTION OF IMPURITIES FROM SOLIDIFYING THYMOL. NOTE AIR BUBBLE *A*, AND CONCENTRATION OF BISMARCK BROWN IN THE MELT ADJACENT TO GROWING CRYSTALS. 100×

fication (*A*), at the expense of the metastable high temperature form (*B*). An entirely new crystal growth is taking place, and the advancing boundary presents faces and angles as well defined as if it were separating from a melt instead of being formed from another solid phase.

The high refractive index of the low-temperature crystals renders their outlines bold and distinct. The transformation is reversible, and is seen going in the opposite direction at a temperature slightly above the transition point (Fig. 14).

As in the microscopic determination of melting points,[1] polarized light enhances the visibility of the phase-change. When one phase is much

[1] Chamot, "Elementary Chemical Microscopy," Wiley & Sons, New York, 1921, p. 225.

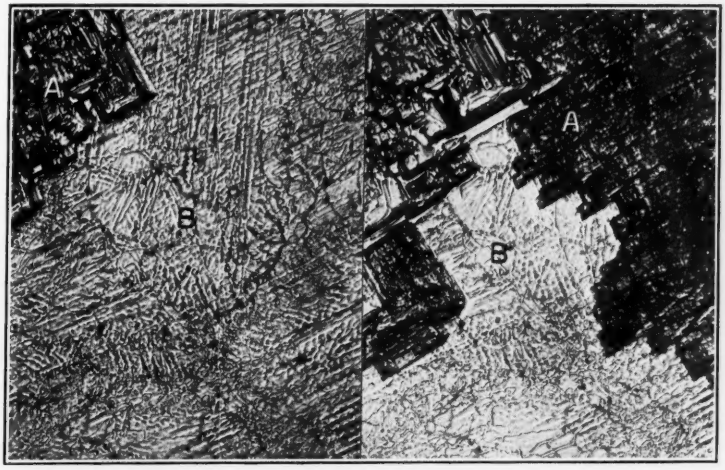


FIG. 12. FIG. 13.

FIG. 12.—ENANTIOTROPIC TRANSFORMATION. ETHYLAMINE HYDROCHLORIDE. LOW-TEMPERATURE MODIFICATION ADVANCING THROUGH METASTABLE PHASE. 50×

FIG. 13.—SAME FIELD AS FIG. 12. TEN SECONDS LATER. 50×

more strongly birefringent (as is the low-temperature modification of ethylamine hydrochloride) it stands out in brilliant colors against the dull gray background of the other phase. Better still, the preparation may be turned between crossed Nicols so that a given area is in the position of "extinction," when the new crystal growth will appear in bright colors against a black ground. The advantage of this procedure is emphasized by Figs. 15 and 16, where the metastable phase is in effect "wiped out" by turning to its position of extinction.

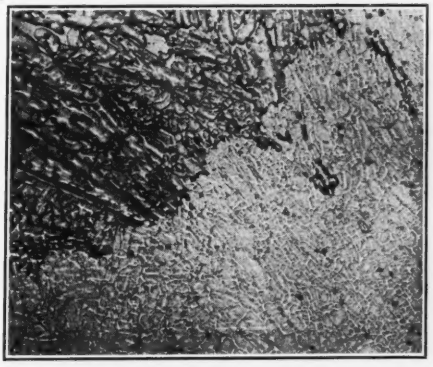


FIG. 14.—HIGH-TEMPERATURE MODIFICATION OF ETHYLAMINE HYDROCHLORIDE, GROWING AT THE EXPENSE OF LOW-TEMPERATURE FORM. 50×

By using an easily regulated hot stage, Anschütz thermometers or a thermocouple, and a polarizing microscope, transition points may be determined to ±0.5° in less than an hour. Systems where

several allotropic modifications, or "liquid crystals"[2] exist may be studied in a similar manner.[3]

The distinction between enantiotropic and monotropic transformations becomes a simple matter, for it is easy by temperature adjustments to send the transformation either way in the former case, while monotropic changes can be made to proceed only in one direction. This is a much more convincing presentation than by means of curves involving pressure changes which are generally negligible in metallurgical work.

Supercooling in solid transformations is very common and is the basis

FIG. 15. FIG. 16.

FIG. 15.—HIGH- AND LOW-TEMPERATURE MODIFICATIONS OF ETHYLAMINE HYDROCHLORIDE. ORDINARY LIGHT. 50×

FIG. 16.—SAME FIELD AS FIG. 15, BETWEEN CROSSED NICOLS. HIGH-TEMPERATURE MODIFICATION (METASTABLE) IN THE POSITION OF "EXTINCTION." 50×

of the heat treatment of steels. By chilling it is possible to cause a metastable solid phase to separate from the melt, and this may show no tendency to invert at ordinary temperatures. The transition of mono-nitronaphthalene from the metastable form (Fig. 17, *A*) to the stable modification (*B*) is inappreciably slow unless the preparation is warmed, when the inversion becomes fairly rapid. This, of course, is what happens in the "drawing" of quenched steels.

In many alloys the outline of the original grains may exist as a "pseudo-

[2] Vorlander, "Chemische Krystallographie der Flüssigkeiten," Akad. Ver., Leipzig, 1924.

[3] Bowen, *J. Phys. Chem.*, **30**, 721 (1926).

morph" after the transformation is complete. Fig. 18 shows this phenomenon in mono-nitronaphthalene. The fine-grained crystals grow entirely irrespective of the previous structure, but still retain some of its fissures and inhomogeneities.

The student ordinarily finds difficulty in relating the overworked *NaCl–H_2O* system to the behavior of molten systems, particularly those of alloys. Numerous low-melting transparent substances are available for demonstration of the various phenomena of two-component systems,

FIG. 17. FIG. 18.

FIG. 17.—MONOTROPIC TRANSFORMATION. MONONITRONAPHTHALENE. DARK, STABLE MODIFICATION; LIGHT, METASTABLE. 50×

FIG. 18.—THE SAME FIELD AS FIG. 17, SHOWING FURTHER REPLACEMENT OF METASTABLE CRYSTALS BY STABLE MODIFICATION. NOTE PSEUDOMORPHIC STRUCTURE. 50×

and by melting these under opposite edges of a cover glass the whole range of compositions from 100% *A* to 100% *B* may be observed, just as in a "diffusion alloy" (Fig. 19). There is the tremendous advantage, however, that this preparation may be observed during its entire solidification range, and may be held at any temperature by means of a hot stage.

Fig. 20 illustrates the whole history of the system *naphthalene-phthalic anhydride* as it cools to complete solidification. At *P* the coarse prisms of phthalic anhydride began to separate as the temperature fell below 130°. At the upper right thin plates of naphthalene (*N*) formed

as the preparation cooled to 80°. Both these phases continued to grow toward the zone of diffusion which remained molten until the eutectic temperature (65°) was reached. The photograph was "snapped" just as the melt began to solidify to a fine-grained eutectic (*E*).

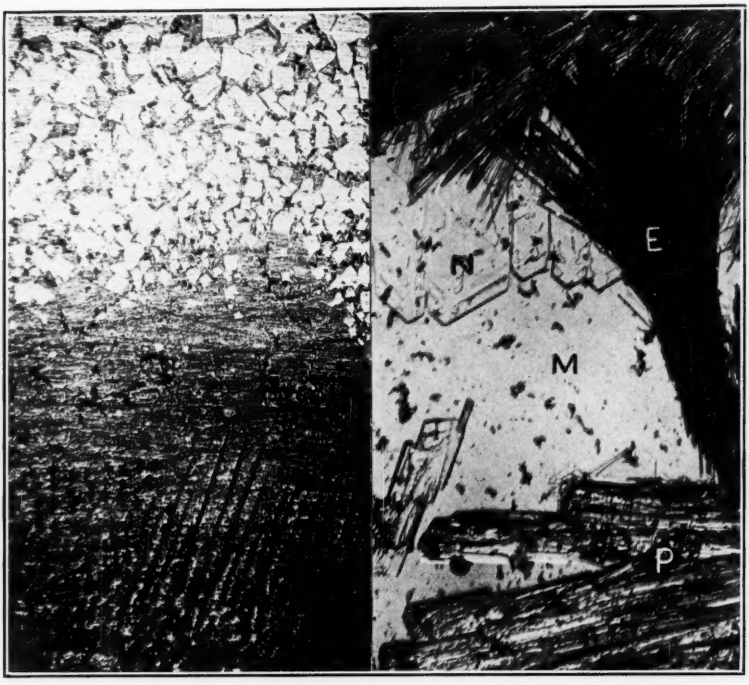


FIG. 19. FIG. 20.

FIG. 19.—DIFFUSION ALLOY. BISMUTH AT TOP, TIN AT BOTTOM, EUTECTIC BETWEEN. 10×

FIG. 20.—NAPHTHALENE–PHTHALIC ANHYDRIDE SYSTEM. *N*, TABULAR CRYSTALS OF NAPHTHALENE; *P*, PRISMS OF PHTHALIC ANHYDRIDE; *E*, FINE-GRAINED EUTECTIC SOLIDIFYING FROM MELT *M*. 50×

On raising the temperature the eutectic melts first, and the whole sequence of changes takes place in reverse order.

All this may be observed repeatedly on a single preparation, even without a hot stage to control the temperature and rate of cooling, and the student's attention may be directed particularly to the nature of the eutectic itself. In most of the illustrative systems, it is possible to recognize that the solidifying eutectic is a composite of the two crystal

forms typical of its constituents, and the common misconception of it as a mysterious third phase is easily cleared up.

Obviously, it is an easy matter to ascertain qualitatively whether any two substances form a eutectic or not, and to determine the temperature at which it separates.

Eutectics in ternary systems may be demonstrated in just as simple and direct a manner. The three constituents are melted under different parts of the cover glass, and allowed to diffuse into each other. On cooling, the pure constituents begin to separate as their respective freezing points are reached, and continue to crystallize until the temperature falls to that of the various binary eutectics, which then solidify at the zones of diffusion. Finally, at the solidification temperature of the ternary eutectic, the region in the center where all three constituents have mixed freezes.

Fig. 21 shows the general appearance of such a preparation of the system *o-nitrophenol* (*O*)–*naphthalene* (*N*)–*sulfonal* (*S*). The three binary eutectics are seen at 1, 2, and 3, and the ternary eutectic is present where all three phases come together. The distinctive crystal form of the three constituents and the distribution of the eutectics is shown on a larger scale in Fig. 22, the ternary eutectic is still molten.

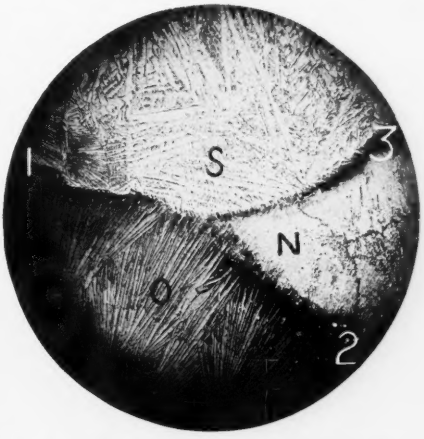


FIG. 21.—TERNARY SYSTEM *o*-NITROPHENOL (*O*)–NAPHTHALENE (*N*)–SULFONAL (*S*). BINARY EUTECTICS 1, 2, 3 AT ZONES OF DIFFUSION BETWEEN PURE COMPONENTS. TERNARY EUTECTIC AT CENTER. 3×

Each of the analogies between metals and non-metallic substances discussed in the foregoing pages may be demonstrated by a number of different materials, and in our course in metallography the general character of the phenomena is emphasized by having different students work with different substances and study each other's preparations. By carrying out the manipulations themselves, and by following the whole series of changes which a preparation undergoes on cooling or heating, the students observe many details of form, color, and behavior which of necessity cannot be recorded adequately by photomicrographs or even by motion pictures.

Some of the materials which lend themselves most satisfactorily to such practices are listed below:

ONE-COMPONENT SYSTEMS

Liquid-Solid Transformations: Thymol, urea, *o*-nitrophenol, sulfonal, salol, benzophenone.

Solid-Solid Transformations: Enantiotropic: Ethylamine HCl, potassium nitrate, silver nitrate, mercuric iodide, sulfur, thallous nitrate (3 solid modifications), ammonium nitrate (4 solid modifications above room temperatures).

Monotropic: Resorcin, hydroquinone, cinnamic acid, mononitronaphthalene, α-monochloroacetic acid (3 solid modifications).

TWO-COMPONENT SYSTEMS

Series of Solid Solutions: Naphthalene–β naphthol; *p*-dichlorbenzene–*p*-dibrombenzene; naphthalene–benzoic acid: cobalt nitrate–nickel nitrate.

Two Solid Phases and Eutectic: Naphthalene–phthalic anhydride; naphthalene–*o*-nitrophenol; naphthalene–sulfonal; sulfonal–*o*-nitrophenol; naphthalene–quinone;

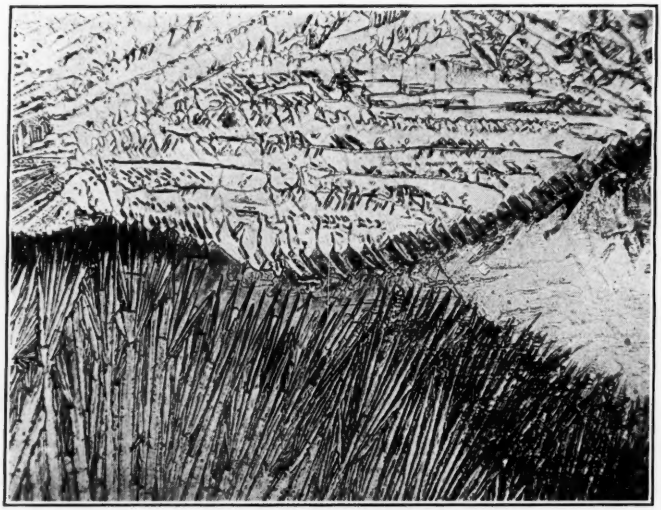


FIG 22.—DETAIL OF TERNARY SYSTEM SHOWN IN FIG. 21. MOLTEN TERNARY EUTECTIC AT CENTER. 25×

naphthalene–thymol; quinone–*p*-dichlorbenzene; quinone–benzophenone; quinone—tetrachlorbenzene.

Three Solid Phases (One a Compound) and Two Eutectics: *p*-Toluidine–salicylic acid; *p*-toluidine–benzoic acid.

THREE-COMPONENT SYSTEMS

Three Solid Phases, Three Binary Eutectics, Ternary Eutectic: Naphthalene–sulfonal–*o*-nitrophenol.

When the student has studied examples of each of the above classes, and has become familiar with the equilibrium diagrams and terminology

used to describe them, he is ready to apply this in the examination of metal specimens. He does not plunge into high-power metallography, however, but spends some time in the study of the surfaces of fractures, ingots, "pipes," and tinned and galvanized sheets, using low-power magnifiers and the Greenough-type binocular microscope to bridge the gap that usually exists between macroscopic and microscopic interpretations.

The discussion of these metal specimens frequently harks back to the introductory practices with transparent materials and since by this time the student has become reasonably familiar with the language of crystallography and phase equilibria, his ideas maintain a certain continuity instead of being separated into unrelated chapters.

He next observes the development of "slip-lines" on the surface of cast lead as it is deformed, and compares the warped crystal grains of this specimen with the "orange peel" texture developed in stamping coarse grained alloys, or at the "neck" in test bars. "Work hardness" is demonstrated as a reality by means of thin strips of soft steel or brass, which bend easily in the fingers but do not readily unbend.

Macroscopic observations of surfaced specimens of cast metals showing ingot structures and dendritic crystals are easily interpreted in the light of the introductory practices with transparent materials.

Surfacing and etching to reveal flow structure produced by deformation in worked metals is followed by study of segregations in steels by means of etching and by "sulfur printing." Macroscopic distinctions between wrought iron and steel are brought out at this stage in the course.

The student is then required to familiarize himself with the optical and mechanical features of the metallographic microscope and with various types of vertical illuminators used in the study of opaque objects. Later in the course he also receives practice in the adjustment of large metallographs, and in using these instruments for taking photomicrographs at standard magnifications, and for determination of "grain size."

Emphasis is placed on methods of preparation of metals for microscopic study, and the student examines the abrasives used, and the character of the surface of the specimen as it leaves each one of them in the various stages of polishing. The specimen is etched lightly, then normally, and finally very deeply, its appearances with different etchants being compared.

Microscopic metallography proper occupies the remainder of the course; students prepare specimens of the common alloys, photographing a number of them. Conference periods are held at intervals, when specimens are compared and their microscopic structure correlated with their thermal diagrams, histories, and properties. Since no two students work on exactly similar samples they thus have the benefit of each other's specimens as well as of other specimens in the laboratory collection.

The various groups of introductory practices do not encroach seriously on the time available for the course in metallography, for the experiments with low-melting transparent materials are ordinarily completed in three laboratory periods. Microscopic studies occupy not more than two periods, general studies on preparation methods another period, so that the microscopic metallography proper is begun the fourth week. By "making haste slowly" at first, the student learns to work intelligently, and although there are no formal lectures in the course he usually does a great deal of voluntary outside reading, so that when he is dealing with the various alloy systems he is continually discussing points of theory and practice with the instructor. This may even extend to fundamental crystallography and phase-rule principles, metallurgical operations, physical tests and engineering uses of the metals.

This broad point of view, spontaneous on the part of most of the students, makes the course much more than simply a sequence of exercises in manipulation, and gives them a concept of the unity pervading the behavior of solids which we believe will be invaluable even if they do not become professional metallographers.

A QUALITATIVE TEST FOR ARSENIC OR ANTIMONY

JACOB CORNOG, UNIVERSITY OF IOWA, IOWA CITY, IOWA

Somewhat by accident, we recently observed that if a test tube, containing water at any temperature up to boiling, is dipped into a solution containing either arsenic or antimony, and then held in the non-luminous flame of a Bunsen burner until the adhering solution is evaporated and the residue adhering to the outside of the test tube is slightly baked, a black mirror is formed. This mirror is similar in appearance to the mirror formed in the Marsh Test for arsenic. The mirror formed by arsenic may be distinguished from the one formed by antimony by the familiar hypobromite test. That is, the arsenic mirror is dissolved by a sodium hypobromite solution while the antimony mirror is not affected in this solution.

Continued heating of the mirror in the flame will cause its disappearance. This test is applicable to solutions in which the concentration of arsenic or antimony is two hundredths molar or greater. Unfortunately, the use of this test is restricted to solutions in which arsenic or antimony are the only metals present. When the ions of metals such as iron or copper are present the test gives indeterminate results. With a little practice, the test is quickly and easily made and where applicable much time may be saved.

ATOMS, MOLECULES, AND IONS*

JAMES B. CONANT, HARVARD UNIVERSITY, CAMBRIDGE, MASSACHUSETTS

An expert has been defined as an ordinary man away from home giving advice. Even under this charitable interpretation, I cannot qualify as an expert on the subject about which I am to speak. On the contrary, I am merely one of the many chemists who have endeavored in the last few years to keep abreast of the times and to discover how many of the new discoveries in physics and chemistry really affect their own bailiwicks.

These have been trying times for those of us who are not specialists in the field of chemical physics. We have heard so many revolutionary statements and so many heated arguments for and against certain electronic theories that at times it seems impossible to put one's feet on solid ground. I propose this afternoon to pass in review from the point of view of an ignorant and skeptical chemist some of the new discoveries and new theories in physics. If there is any originality in my treatment of the material, it will rest solely in the fact that I shall try to emphasize the experimental data and to contrast that which seems to be reasonably certain with what must be taken as only possibly true. This will be particularly the case with regard to the so-called electron theory of valence and the Bohr model of the atom. These excellent scaffoldings which have been so useful to the physicist and to some extent to the chemist are now being somewhat rebuilt under the influence of Schrödinger.

Atoms

The new physics and chemistry in many ways center around the periodic table. Instead of assigning to each element a position by virtue of its atomic weight, we now make use of the results of x-ray spectroscopic investigations and arrange the elements according to their atomic numbers.

I shall not attempt to go into even the elementary theory back of the x-ray spectrometer, although the accompanying figure (Fig. 1) will show the general principle; indeed, all of you are probably already familiar with it. From the point of view of the elementary student the analogy between the x-ray spectrometer and the spectroscope seems well worth emphasizing. Indeed the x-ray spectra are remarkably simple compared to the visible spectra and their significance much easier to ascertain.

It is possible to arrange the elements in such an order that a given pair of lines in the x-ray spectra of each appears to have been progressively

* Presented at a joint meeting of the New England Association of Chemistry Teachers and the Eastern Association of Physics Teachers, at the East Boston High School, Boston, Mass., on May 14, 1927.

and regularly shifted to the left (showing a decreasing wave-length) as one proceeds from the lighter to the heavier elements (Fig. 2). This arrangement of the elements on the basis of their x-ray spectra is found to be exactly like the old series based on atomic weights, *except* that now the pairs of elements, tellurium and iodine, argon and potassium, and cobalt and nickel, are no longer reversed but fall into their proper places.

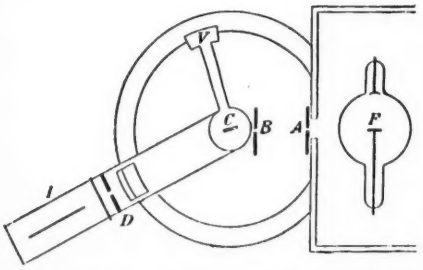


FIG. 1.—X-ray Spectrometer as used by W. H. Bragg. The rays are limited by two lead slits, *A* and *B*. The crystal is mounted at *C*. The reflected beam is limited by a third lead slit, *D*. Sometimes a photographic plate is substituted for the ionization chamber, *I*.

The chemical properties of the elements are a periodic function of their positions in a series determined by their x-ray spectra. Unlike the old periodic law involving atomic weights, this statement is exact.

Since not all elements can be conveniently made into anti-cathodes, there are still some experimental gaps in the series which obviously correspond to known elements; and in addition there are a few gaps corresponding to elements which are as yet undiscovered. The number corresponding to the position of the element in this new series, if we take hydrogen as one, is called the *atomic number* of the element. A concise formulation of the new periodic law is, therefore, as follows: the chemical properties of the elements are a periodic function of their atomic numbers.

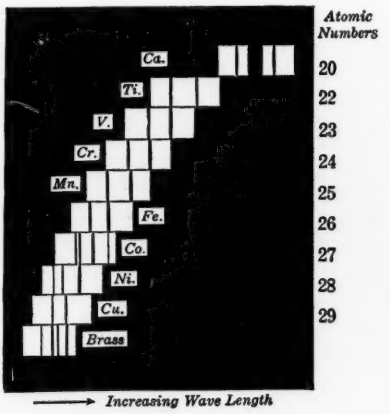


FIG. 2.—X-ray spectra.

A convenient periodic table based on this new periodic law is shown in Fig. 3. It will be noted that the atomic weight is put under the symbol of the element and the atomic number in the upper left-hand corner of each square. The elements printed in italics and enclosed in heavy lines form the middle of the old long periods. It is evident that the periodicity of chemical properties in terms of the atomic

number occurs in such a way that we have (leaving out hydrogen) two short periods of eight elements each, and then two long periods of eighteen elements each. Beyond this point the relationship is less simple, partly because of the complication of the rare earths.

The Positive Nucleus

Now for the interpretation of the experimental data. Rutherford first postulated the existence of a positive nucleus in each atom to explain the scattering of α particles (from radium) by matter. I think we need not depart too far from the attitude of the "skeptical chymist" to consider the reality of this positive nucleus as well established—though I

Periodic Table showing Atomic Numbers and Valences

Period	Group 0	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
0		1 H (1) 1.008							
I	2 He (0) 4.00	3 Li (1) 6.940	4 Be (2) 9.02	5 B (3) 10.82	6 C (4) 12.000	7 N (5) 14.008	8 O (6) 16.000	9 F (7) 19.00	
II	10 Ne (0) 20.2	11 Na (1) 22.997	12 Mg (2) 24.32	13 Al (3) 26.97	14 Si (4) 28.06	15 P (5) 31.027	16 S (6) 32.064	17 Cl (7) 35.457	
III	18 A (0) 39.91	19 K (1) 39.096	20 Ca (2) 40.07	21 Sc 45.10	22 Ti 48.1	23 V 50.96	24 Cr 52.01	25 Mn 54.93	26 Fe 27 Co 28 Ni 55.84 58.94 58.69
		29 Cu 63.57	30 Zn 65.38	31 Ga 69.72	32 Ge 72.60	33 As (5) 74.96	34 Se (6) 79.2	35 Br (7) 79.916	
IV	36 Kr (0) 82.9	37 Rb (1) 85.44	38 Sr (2) 87.63	39 Y 88.9	40 Zr 91.	41 Cb 93.1	42 Mo 96.0	43 Ma ?	44 Ru 45 Rh 46 Pd 101.7 102.91 106.7
		47 Ag 107.880	48 Cd 112.41	49 In 114.8	50 Sn 118.70	51 Sb (5) 121.77	52 Te (6) 127.5	53 I (7) 126.932	
V	54 Xe (0) 130.2	55 Cs (1) 132.81	56 Ba (2) 137.37	57-71 Rare Earths	72 Hf 180.8	73 Ta 181.5	74 W 184.0	75 Re ?	76 Os 77 Ir 78 Pt 190.8 193.1 195.23
		79 Au 197.2	80 Hg 200.61	81 Tl* 204.39	82 Pb* 207.20	83 Bi* 209.00	84 Po* 210.0	85 —	
VI	86 Rn (0) 222.	87 —	88 Ra* (2) 225.95	89 Ac* 227	90 Th* 232.15	91 Pa* 230.?	92 U* 238.17		

FIG. 3.—The *atomic number* appears before the symbol of each element and the *atomic weight* below. The number of *valence electrons* is in parentheses. The atomic weights of Po, Ac, and Pa are calculated values. At the places marked * are to be assigned a number of other elements, for the most part radioactive, which have the same chemical properties as the element in the table but somewhat different atomic weights.

think it would be going much too far to call it a "fact." At least we may say that it seems impossible to correlate a great many different experimental facts without assuming a nucleus in each atom having essentially the mass of the atom and a positive charge.

Rutherford's experiments had lead him to believe that there was at least an approximate correlation between the scattering power of an element and its atomic weight. Since he had postulated that the magnitude of the charge on the positive nucleus determined the amount of scattering, he summed up the situation as follows: "The general data available indicate that the value of this central charge for different atoms is approximately proportional to their atomic weights, at any rate for atoms heavier than aluminum."

Moseley undertook his famous work in order to investigate this point

by an entirely different and more rigorous method. The result was Moseley's law connecting the wave-length of the x-ray spectral lines and the position of the element in a series (the atomic number). We have just discussed the significance of this discovery in relation to the periodic law. From the point of view of the physicist, the atomic number is the net charge on the positive nucleus, since the present physical explanation of the emission of x-rays leads to an equation involving the magnitude of this nuclear charge.

If the charge on the positive nucleus determines the atomic number of the element (its place in the periodic table), it is conceivable that one could turn one sort of atom into another by modifying the nucleus. The artificial production of such a change is a very doubtful point, as I will

LAST TWO ROWS OF THE PERIODIC TABLE SHOWING POSITION OF THE DISINTEGRATION PRODUCTS OF RADIUM

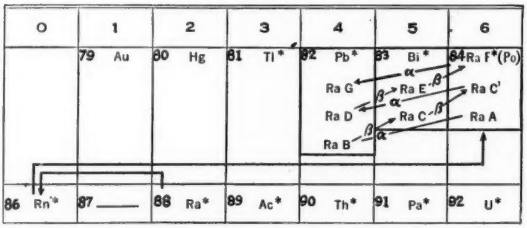


FIG. 4.—The positions marked by a star (*) are occupied not only by the elements given but by the disintegration products of the Thorium-Uranium series. Note that in the change from Rn (radon) to Ra A, the change from the zero group of one row to the sixth group of the *higher* row is equivalent to moving two positions to the left in the same row (α change). Radium F is also called Polonium (Po).

mention later, but nature has provided a remarkable series of elements where this process goes on for us. The facts elucidated by a study of radioactivity are among the most important which have led to the new ideas concerning the structure of atoms.

Evidence from the Disintegration of Radium

The accompanying figure (Fig. 4) shows the position in the periodic table of the disintegration products of radium. Radium having the atomic number of 88 (with the chemical properties of group 2) loses a doubly charged helium atom (alpha particle) and is converted into radium emanation, now called radon (atomic number 86). This member of the rare gas family loses another doubly charged helium atom and becomes radium A of atomic number 84, which in turn becomes radium B with the number 82. These are all so-called *alpha* changes and, as would

be expected from the concept of a positively charged nucleus, each loss of two positive charges from this nucleus yields an element of atomic number two lower. On the other hand, a so-called *beta* change involves the liberation of an electron *from the nucleus*. In terms of our theory the positive nucleus thereby gains a positive charge, and the newly formed element has an atomic number one greater.

It must, of course, be remembered that all these changes are occurring spontaneously at a rate entirely independent of anything the chemist can do. Some of the changes are so rapid that the life of one of the elements is half over in a few minutes. In many of the cases, the amounts of the substances involved have been too small to see or even weigh. The results are nevertheless beyond dispute, thanks to the accuracy of the physical methods of measuring the characteristics of these elements.

There seems no other way of explaining the remarkable regularities of these radioactive changes except on the basis that we are here dealing with spontaneously exploding nuclei and that the alpha particle and electrons both come from within this tiny nucleus.

Isotopes

The study of radioactivity first revealed to the chemist that a chemical element might be a mixture of two or more substances of the same atomic number but with *different* atomic weight. A glance at Fig. 4 shows that ordinary lead, radium B, D, and G, all have the same atomic number (82) and, therefore, identical chemical characteristics but different atomic weights. These elements are *isotopic* with one another. Isotopes are identical in chemical properties and differ only in atomic weight, density, and other properties involving atomic mass. It has been shown that samples of certain kinds of lead found in radioactive ores have an atomic weight of practically 206, as compared with ordinary lead of atomic weight 207.2. Every expulsion of a helium atom in the form of an alpha particle should lower the weight of the element by 4 units. There are five such changes between radium and radium G, the end-point of the series. Subtracting these twenty units from the atomic weight of radium gives 206, the atomic weight of radium G. The experimental demonstration of the existence of two kinds of lead, identical in chemical properties and x-ray spectra but different in properties involving atomic mass, was the first proof of the existence of isotopes.

Subsequently, the physicist Aston showed that isotopes are not confined to the last place in the periodic table, but that many of our common elements are mixtures and that their atomic weights are averages. These results were gained through a study of the behavior of individual charged atoms moving rapidly in a highly evacuated tube under the influence of an electric discharge. By determining the effect of electric and mag-

netic fields on the path of these atoms (as recorded by their effect on a photographic plate) Aston was able to calculate the mass of the atom. This work is remarkable not only because of the significance of the results obtained, but because we have here an experimental study of practically individual atoms; although, to be sure, the action on the photographic plate is due to the action of a multitude of individual atoms following each other on the same path.

Mixtures of isotopes are inseparable by chemical methods, but may be separated with great difficulty by diffusion processes. This has actually been done in the case of mercury and chlorine, but the separation is far from complete, since the isotopes differ but slightly in mass. For all chemical purposes a mixture of isotopes is a constant, definite element.

It is significant that the atomic weights of the individual isotopes are very nearly whole numbers, though the conglomerate of isotopes which we know as a chemical element may have an atomic weight far removed from an integer. For example, chlorine, whose atomic weight is 35.46, has been shown by Aston to be a mixture of two isotopes of atomic weights 35 and 37 in such proportions that the mean value is 35.46.

Are all the elements composite substances made of some simpler parts, such as hydrogen nuclei and electrons? The fact that the atomic weights were not whole numbers killed a similar attractive hypothesis in Prout's time; can it come to life again now that we know that the atomic weights of the individual isotopes are very nearly whole numbers? Many scientists today answer these questions in the affirmative. Certainly in the case of the radioactive elements we are dealing with composite atoms. If the hydrogen nucleus (often called a *proton*) and electrons are the building stones of the nuclei of all the atoms, the structure of all matter has been reduced to very simple terms indeed. According to this modern Prout's hypothesis, the helium nucleus with net charge 2+ is composed of four protons (4+) and two electrons (2−); other nuclei may be imagined as similarly constructed. There are certain relatively slight discrepancies in mass since the atomic weight of hydrogen is 1.008 and not 1.000, but these can be accounted for in terms of modern physical theory.

The idea that the nuclei of all atoms are composite at once suggests the possibility of breaking down complex atoms into simpler ones—a transmutation of elements. Such a process is going on all the time in the case of the radioactive elements as we have seen, but we know of no method to hasten or retard it. The experiments of Rutherford in which he obtained hydrogen by the bombardment of nitrogen by alpha particles represents in a sense the first artificial "transmutation" of elements. But it is well to remember that the amounts of matter so transmuted were so small as to escape discovery by any chemical method. Furthermore, since a radioactive element was used as the source of energy,

the use of the term *artificial* disintegration has been questioned. The sum total of the process is simply this, that the disintegration of a radioactive element under certain conditions can bring about the disintegration of a small amount of another element. Whether or not the change of one element into another can be brought about by other means than by subnuclear forces (for instance, by means of electric currents) is still a much disputed point. No generally accepted case of clearly artificial transmutation is known, though there seems to be no reason to believe that such processes are intrinsically impossible.

Molecules and Ions

So far, I have dealt chiefly with the structure of the atom and even flirted with the structure of the nucleus. I shall now briefly consider some problems rather more chemical in nature, namely, those concerned with the structure and formation of compounds. By means of the x-ray it has been possible to decide the positions of the structural units in a crystalline solid. In the case of sodium chloride, the results are remarkably simple as shown in the accompanying figure (Fig. 5). A number of other common salts similarly show a "space lattice" in which there seems to be no grouping of one positive element with another negative element, but rather a uniform distribution of both elements. On the other hand, some inorganic substances such as certain oxides (*e. g.*, Fe_2O_3, As_2O_3, Cr_2O_3, Al_2O_3, and SiO_2) and tin tetraiodide, and probably all organic substances show a quite different sort of structure. These are illustrated in Figs. 6, 7, and 8. It will be noted that here we are dealing with definite groups of atoms, these groups in turn forming a crystalline unit. These groups are in most instances the molecules, and the x-ray has given us a

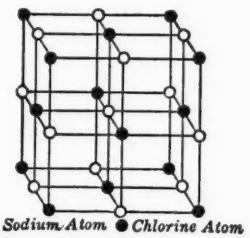


FIG. 5.—Atoms in a crystal of common salt.

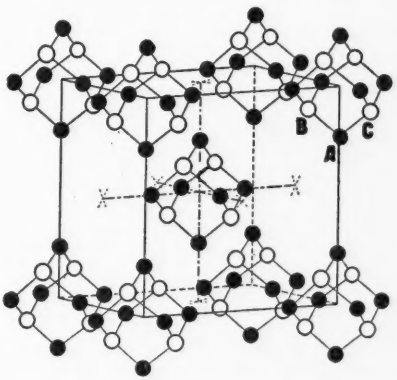


FIG. 6.—Arrangement of the carbon atoms (black circles) and nitrogen atoms (white circles) in $C_6H_{12}N_4$ (hexamethylene tetramine) crystals.

method of demonstrating their existence in a solid with considerable certainty. It is perhaps not out of place to note that some popular writers have mistaken the results with sodium chloride as being the whole story and have stated that modern physics has shown the non-existence of the molecule in solids. Nothing could be farther from the truth.

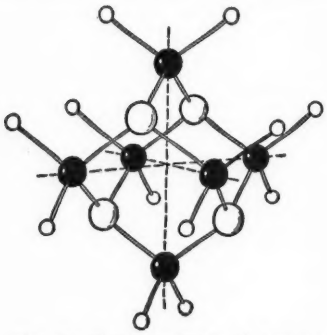


FIG. 7.—Single molecule of $C_6H_{12}N_4$ (hexamethylene tetramine) the small white circles represent hydrogen atoms. Perspective.

Returning to the structure of sodium chloride, we can either imagine that the uniformly spaced atoms are sodium atoms and chlorine atoms, or that they are sodium ions or chlorine ions. There are a number of facts which I believe the physicists can bring forward to support the latter contention and in view of what we know of the properties of salts it seems the rational one. The crystal of a salt, like sodium chloride, is thus probably made up of ions held together by electrostatic attraction. When the salt dissolves in water, the ions are loosened and are free to move. The same is true if we melt a salt. Such compounds (often called polar) are to be contrasted with organic substances (and some inorganic substances which are not salts) where we do not have an electrolyte formed on dissolving the material. As far as the evidence at present is available, we can say that these non-polar compounds almost always show, on x-ray analysis, a grouping of atoms corresponding to a real molecule.

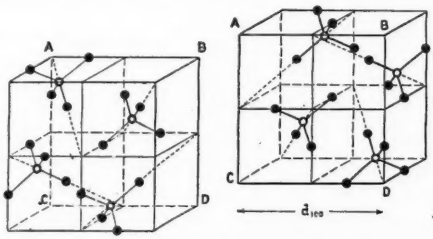


FIG. 8.—Arrangement of the atoms in tin tetraiodide; the unit cube has been divided along the plane ABCD to avoid superposition of the atoms in the figure.

Valence in Non-Polar and Polar Compounds

Concerning the forces which hold the atoms together in the molecules of non-polar substances, we are completely in the dark. I say this with all due respect to the brilliant theory of Lewis and to its extension by Langmuir and others. There are some interesting hypotheses concerning the nature of a non-polar union, but they are certainly at present in an entirely different category of probability from the simple points which I am trying to emphasize this afternoon. In regard to the problem of valence

in such non-polar molecules as the hydrogen molecule, the carbon dioxide molecule and the methane molecule (and practically all of organic chemistry), the new ideas have given us no sure clue and there is no agreement among the contending theories. To say that the electron theory has "explained valence" is to forget the existence of at least half of all chemistry!

Since in the simple salts we are dealing only with an aggregate of ions, the problem of valence is quite different. Here, if we know the rules relating to the formation of ions from atoms and can find some probable reason for these rules, we can claim to have "explained" this class of compounds. This can be fairly well accomplished in the case of the first twenty elements in the periodic table. Returning to our picture of the atom, it will be evident that in order to have an electrically neutral atom there must be some negative electricity to counterbalance the positive charge on the nucleus. To explain the periodicity in chemical properties and a great many physical and chemical facts, it has been suggested that the negative electricity is in the form of electrons which range themselves in layers or shells: the first shell contains two electrons and the next two shells, eight each. The most elaborate and complete theory of this sort is the one put forward nearly fifteen years ago by Bohr and slightly modified by him from time to time. I am sure all of you are familiar with the fundamentals of this theory, and I need but to call them to your minds as regards their chemical significance. The lack of reactivity of helium, neon, and argon is attributed to the fact that in each of these rare gases we have completed groups or shells of electrons, the first having a group of two, the second a group of two surrounded by a group of eight and the third (argon) two large groups of eight surrounding the inner group of two. It was further supposed that this rare gas arrangement of electrons was the most stable and that all other atoms would tend to take on this arrangement by virtue of a gain or loss of electrons. Thus, the lithium atom by losing one electron from its total of three has a structure resembling the helium atom, but carrying a positive charge. This is the lithium ion. Similarly, the sodium ion is like neon, the potassium ion like argon, as far as the arrangement of the electrons is concerned. In the case of the strongly electronegative elements, such as the halogens, it is supposed that they can acquire a sufficient number of electrons to make up a group of eight. Thus, fluorine with seven takes up one electron and becomes the fluorine ion, similar to neon in electronic structure. The sulfur atom, with six electrons, acquires two and becomes the sulfide ion, analogous to argon. The following figure (Fig. 9) shows a diagrammatic scheme indicating the arrangement of electrons in the isotopes of chlorine on the basis of this theory. If we were to add one more electron to the outer ring, we should have the chloride

ion. While the theory works excellently for polar compounds (that is, salts) of the first twenty elements, there are considerable difficulties met with in its application to the long periods. I shall not deal with these. It is an interesting and useful rule to remember that the elements in the middle of these long periods are the ones that show variable valence and form colored ions.

Revision of the Ionization Theory

The ionization theory has been revised in the last few years partly as an outcome of the new point of view in regard to the structure of the crystals of simple salts. In the case of such substances as sodium chloride, the undissociated molecule has been discarded. This has been accepted with enthusiasm by almost all. The simple theory of ions made its quantitative calculations on the assumption that the gas laws could be applied to a solution of these charged particles. The new theory of Debye started from the point of view that a solution of a salt is very different from one of sugar because we are dealing with highly charged particles and we must take into account the electrostatic forces. He has been able to develop a theory which correlates many of the old and apparently hopeless data concerning the so-called degree of dissociation of strong electrolytes. According to the new point of view the change in conductivity of sodium chloride solution on dilution is not due to an increase in dissociation, but to the different electrical conditions prevailing in concentrated and dilute solutions of highly charged particles. Qualitatively, the picture given by the new view of salt crystals and total ionization is really simpler than the old concept. In interpreting the common ion effect with strong electrolytes and the formation of precipitates we should do well nowadays to use an explanation involving the direct combination of ions to form a solid, rather than to introduce another equilibrium involving the now discarded non-ionized molecule. Thus:

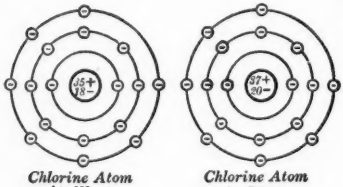


FIG. 9.—Isotopes of chlorine.

Old view

$$Ag^+ + Cl^- \rightleftharpoons \underset{\text{(undissociated molecule)}}{AgCl} \leftrightarrows \underset{\text{(solid)}}{AgCl}$$

New view

$$Ag^+ + Cl^- \rightleftharpoons \underset{\text{(solid)}}{AgCl}$$

There seems to be no reason, however, to change our ideas concerning the dissociation of weak electrolytes, which have been found to follow

quantitatively the predictions made on the basis of an equilibrium involving an undissociated molecule (Ostwald's dilution law). Thus

$$\underset{\substack{\text{(undissociated}\\ \text{acetic acid)}}}{H[C_2H_3O_2]} \rightleftharpoons H^+ + C_2H_3O_2^-$$

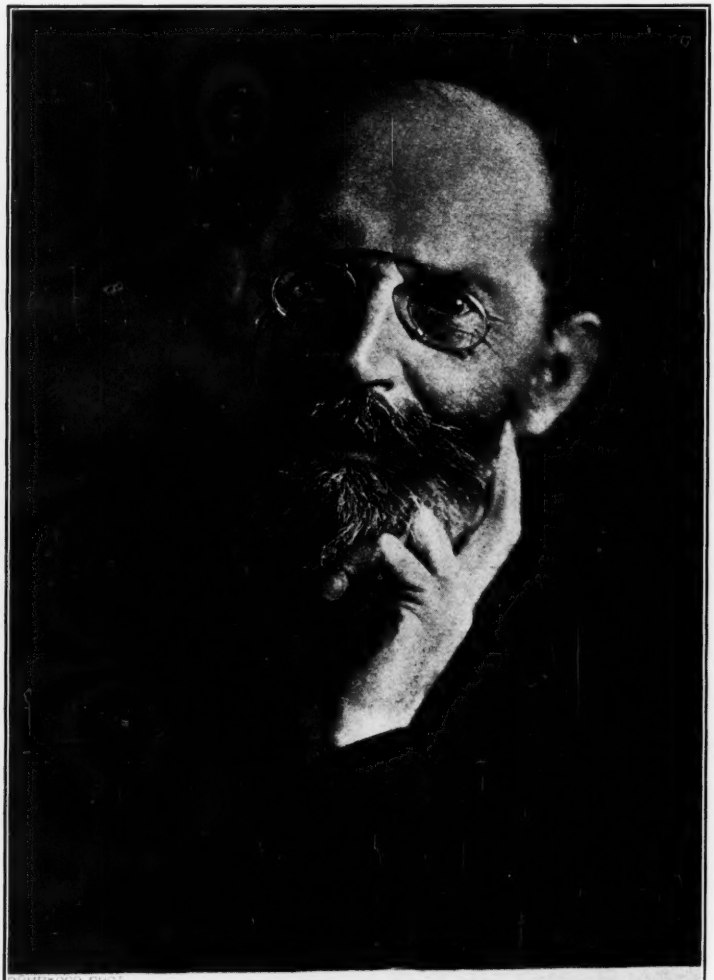
Changes in the Physicists' View of the Atom

In the last year, the status of the Bohr theory of atomic structure has rapidly changed. All admit that it has been of extreme value and probably still is the most satisfactory working hypothesis in many fields. That it represents the real state of affairs, however, seems unlikely in the opinion of those most competent to know. I am here on even more uncertain ground than in the rest of my talk and will content myself with quoting from a recent paper by one of the brilliant young chemists who is following the most recent advances in physics and is foremost in interpreting the Schrödinger ideas.

> This model of the hydrogen atom accordingly consists of a nucleus embedded in a ball of negative electricity—the electron distributed through space. The atom is spherically symmetrical. The electron density is greatest at the nucleus, and decreases exponentially as r, the distance from the nucleus, increases. It remains finite, however, for all finite values of r, so that the atom extends to infinity; the greater part of the atom, however, is near the nucleus—within 1 or 2 Å..... The chloride ion may be described in the following words: the nucleus is embedded in a small ball of electricity, consisting of the two K electrons, with a trace of the L and M electrons; surrounding this are two concentric shells, containing essentially the eight L and the eight M electrons.

This is certainly a complex picture and perhaps at present unintelligible to the non-mathematically minded. It should be pointed out that as far as most of the interpretations are concerned which I have given this afternoon, we do not have to modify them essentially even in terms of the very recent ideas. If we define valence electrons not in terms of the Bohr model, but merely as the number of negative charges which the atom can gain or lose in making up the mystic number of eight, we are in a safe position, always with the proviso *that we stick to polar compounds of the first two rows of the periodic table.* For the present this seems to me sufficient for those of us who are not actively engaged in trying to unravel the complexity of atomic structure. The passing of the Bohr atom may well remind us, however, that we should be cautious about being dogmatic in presenting even a very satisfactory theory.

If we learn to dream we shall perhaps discover truth. But let us beware of publishing our dreams until they have been tested by the waking consciousness.—KEKULÉ



Emil Fischer

EMIL FISCHER

LUDWIG DARMSTAEDTER, PRUSSIAN STATE LIBRARY, BERLIN, AND RALPH E. OESPER, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

In a paper entitled "On the Constitution of the So-Called Carbohydrates" published in 1871, Rudolf Fittig stated that the simple sugars contain aldehyde groups. The proof of this assertion was furnished in 1885 by Heinrich Kiliani, when he succeeded in building up sugars richer in carbon from others poorer in this element. The decided aldehydic nature of the sugars led Emil Fischer to test the action of phenylhydrazine on these compounds, for this reagent which he had discovered had proved particularly useful in characterizing aldehydes. The results were eminently successful. In 1887 Fischer and Tafel prepared the first simple sugars by the action of baryta water on acrolein dibromide. The sirupy product was treated with phenylhydrazine and so found to contain two isomeric sugars, the acroses. Such sugars are prepared more easily by condensation of formaldehyde and glycerose, an oxidation product of glycerine. In this way Fischer obtained grape sugar (glucose) and fruit sugar (fructose). As a result of such studies, Fischer was able to go from sugars containing five atoms of carbon to those containing six, seven, eight, and nine atoms of this element, so that he was in a position to declare: "If time, labor and money are not spared, it will be possible to ascend several rungs higher on this ladder." Although only six simple sugars were known before Fischer's time, now more than fifty of these compounds have not only been prepared, but their constitutions and geometrical configurations have been elucidated. Eduard Hjelt, the chemical historian, wrote: "These investigations, because of their range and significance, will be an imperishable honor to not only synthetic but also to stereo-chemistry." Although the synthesis of these sugars has not yet been of great technical importance, and it is questionable whether this will be realized within a perceptible time, this achievement has been of great value for biochemical researches.

Hermann Emil Fischer was born in Euskirken, Rhenish Prussia, on October 9, 1852. After several years of private elementary instruction, he was sent, at the age of nine, to the local public school. He was a brilliant and successful pupil, characterized above all by a phenomenal memory. In his early years he showed a decided talent for mathematics but this field later had little interest for him. When thirteen he attended the gymnasium at Wetzlar, transferring in 1867 to a gymnasium at Bonn, where he finished the course in 1869. Emil wished to study physics and chemistry, but this did not agree with his father's wishes. The latter believed that the chief end of man was to improve his material condition and to amass goods more tangible than scientific facts, and accordingly he decided that Emil should enter the lumber concern of his son-in-law, Max

Friedrichs. The boy was very unhappy in his new surroundings; he procured a copy of Stöckard's "Schule der Chemie," and began to perform all sorts of chemical experiments in a vacant room of the establishment. His brother-in-law discovered what he was doing, scolded vigorously, and was heartily seconded by Emil's father. Finally, in desperation, the father solaced himself by saying: "The boy is too stupid for a business career, he had better study." The father died in his ninety-fifth year and Emil wrote in his autobiography: "I regret that my father did not live to see his impractical son receive the Nobel Prize in chemistry. Later, the yearly income from some of my discoveries was greater than he himself had ever enjoyed."

After spending the winter of 1870–1871 with his uncle, Otto Fischer, a physician in Cologne, Emil went to Bonn and began working in Kekulé's laboratory. He was not satisfied with the laboratory instruction there, and in 1872, he and his older cousin, Otto Fischer, decided to study with Baeyer at Strassburg. Here Emil found what he desired; he passed his doctorate examination in 1873 and was immediately appointed assistant in the organic division. In 1875 he discovered phenylhydrazine. The great reactivity of this material has often been advantageously employed for synthetic purposes, and Fischer himself found it an invaluable aid in his work on the sugars. At the close of 1875, he followed Baeyer, who had become the successor of Liebig, to Munich and continued his work there, teaching privately. In 1876, he and his cousin Otto showed the close relationship of fuchsine to triphenyl methane, and thus cleared up the chemistry of the rosanilines. In 1877 Emil received his license to teach, and in 1879 he was appointed to succeed Jakob Volhard as director of the analytical division, and in 1881 he again took the place vacated by Volhard, this time as professor at Erlangen where he stayed four years.

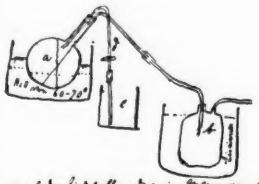
He opened a fruitful field of research, when, in 1883, he found that indole derivatives are formed by condensation of hydrazines with aldehydes, ketones, and ketone carboxylic acids. One of these newly discovered bodies was skatole, whose terrible odor is so persistent that Fischer was almost forced to leave a hotel in Ajaccio, Corsica, because his trunk contained an old laboratory coat. Other important discoveries were made by his students at Erlangen, notably those by Knorr on pyrazolones, especially antipyrine. In 1885, Fischer moved to Würzburg. The laboratory was very bad; the construction of the promised new institute was postponed time after time, but still the most beautiful investigations issued in a steady stream from these unfavorable surroundings. The papers dealt with subjects of prime importance, such as the preparation of the first synthetic sugars; the synthesis of morpholine by Knorr; the ester condensations by Wilhelm Wislicenus, the studies on strychnine by Tafel, etc. In his autobiography "Aus meinem Leben" Fischer tells of the preparations which

1927.97

Würzburg 27. II. 89.

Hochgeehrter Herr Collega

Wir haben bisher ein Laboratorium
alle Verdunstungsflüssigkeiten mit Glasgefässen
ausgeführt.
Bei grösseren Quantitäten dieser
flüchtigen Körper 3 Liter von 2 Liter Inhalt
Einfluss in folgender Anordnung.



a ist die Destillirblase, die in Wasser von 50-70° steht.
Der Hals der Blase ist in a und den übrigen Apparaten
mit Gummi ..... verbunden. Der Kolben a enthält eine

wenige Cem. Schwefelsäure, mit der die Wasserpumpe
verunreinigt werden, um die Dämpfe zu absorbiren.
Die Leitung steigt aus dem Gefäss c durch den
Kork d, reicht nicht ganz bis auf den Boden,
wie der Kork, wenn die Flüssigkeit abspritzt,
in die Leitung spritzt.
A ist ein Dreiweg-Hahn, welcher Leitung für
Luft abschließt.
Alle Fugen sind gut mit Vaseline, aber
sehr gut mit gutem Glycerin.
Man muß aber vorsichtig sein und nicht
zuviel nehmen.
Will man Luft hineinlassen, so kann man einen
Dreiweg einschalten.
Ist der Vorrath groß genug, so kann
man etwa 5 Liter in einer Operation ver-
dampfen.
Wir haben so an einem Tage noch 10 Liter
verdampft.
Wie erwähnt genügt bei 30-40 mm.
Ist der Hahn nicht gut, so kann man
an seine Stelle [illegible], welche
Leitung wie in meinem Apparat mit
Hahn und Glasrohr mit Gummi in
Verbindung steht, setzt einen Tropfen
Glycerin, der durch Luft eingetrieben wird.

Die richtige Regulirung [illegible] mit der
Hand geht, ist es wenig Übung erfordert
Für die Metall-Apparaten habe ich mich bisher
nicht entschieden können.
Hat man Mengen über 100 Liter zu
verarbeiten, so muß man natürlich
doch gezwungen sein. Wir sind schon
2 mal in der Lage gewesen und haben
damit den Apparat wie an
großen Apparaten an den Leitungen
für Hähne ausgeführt.
Ist der Hahn dicht wird Vakuum genügt,
daß Gefäß ganz sauber und ganz dicht
zu bekommen.
Schließlich sende ich Ihnen das Schema
der Kühlung [illegible] eine mit
besserem Kühler zu versehen
Wie die eingeschlossen aus den beigegebenen
Proben haben werden, ist die Ausbeute
eine gute Manneose normal.

Mit freundlichem Gruße
Ihr Emil Fischer.

Letter from Emil Fischer to Heinrich Kiliani describing an apparatus for concentrating solutions in vacuo. Includes a device for introducing the solution without dismantling the set-up.

he and his staff made on the occasion of the visit of the governmental committee appointed to investigate the real need of a new laboratory at Würzburg. "We decided to greet them, not with flowers, or with maidens dressed in white, but with the much more effective odorous products of chemical activity. Bromine, hydrogen sulfide, ammonia, mercaptan, skatole, isonitriles, cacodyl, etc., served to fill the laboratories with an infernal stench and demonstrated the cramped space and inadequate ventilation *ad nasum*. I can still recall the astounded look of the gentlemen of the commission, who valiantly worked their way through the odors, and when we finally arrived in the basement, the whole company took a deep breath and agreed that the air here was by far the best." The scheme worked, but the committee was not fooled, for during a later discussion of the plans one of the members asked Fischer: "What guaranty have we that such asininity will not be repeated?"

In 1888, Fischer married Agnes Gerlach, daughter of a professor in Erlangen and he confessed that the marriage was an obvious result of the machinations of some of the faculty ladies who could not rest as long as such an eligible young bachelor was in their midst. The union was perfectly happy and Fischer was greatly grieved when his wife died in 1895, leaving him with three young sons, only one of whom survived the father.

Fischer delivered a lecture before the German Chemical Society on June 23, 1890, on the status of the chemistry of the carbohydrates. His closing paragraph reads: "Since organic synthesis, armed with its heritage of beautiful methods of the old masters, has, in the short space of sixty-two years, emerged victorious from the conflict with urea, the fats, many acids, bases and vegetable coloring matters, and has vanquished uric acid and the sugars, therefore it appears to me that our science need not fear to join battle with any product of the living organism."

In 1892 Fischer agreed to succeed A. W. Hofmann in Berlin. One of his demands was the erection of a new laboratory, but it was seven and a half years before the new institute was opened for work. In the meantime he had to make the old laboratory serve and it did. A general method of preparing artificial glucosides was discovered in 1893. He found that there exists no fundamental difference between the glucosides and the polysaccharides and that, in general, the latter may be produced by procedures which lead to the formation of glucosides. The year 1894 marked the appearance of the enzymic methods of splitting sugars. From 1895 on Fischer perfected his syntheses in the pyrine group, preparing caffeine, theobromine, xanthine, hypoxanthine, guanine, and adenine. He demonstrated the relation of these to the parent substance, purine, which itself was prepared after considerable difficulty.

In 1901 Fischer began his work on the synthesis of albumen. He started by studying the amino-acids which are the lowest scission products of

the proteins. Curtius had worked out the preliminary stages in this field, but Fischer made a big advance when he discovered the "ester" method for separating the amino-acids, compounds which are, in a measure, the bridge between the proteins and the plant alkaloids. By coupling the amino acids, Fischer produced the dipeptides, and then the polypeptides, of which he prepared about one hundred different examples. As the chains in the polypeptides increased in length, the products resembled more and more the natural albumens, the so-called peptones. The action of enzymes on these polypeptides showed their close relationship to the peptones and proteids. The molecular weight of his octadeca peptide is 1213, but this falls far short of the molecular weight of the simplest natural peptides. Fischer believed that the synthesis of more complex products was only a matter of trouble and cost.

Fischer and von Mering, in 1903, discovered new soporifics belonging to the so-called veronal group. These are di-alkylated barbituric acids. The most important of these were veronal and propanal, which are widely used in medicine. He patented these and other medicinals, but regarded them as of only incidental importance. He wrote to Baeyer that these things had but little interest for him, and that his one desire was to prepare the first artificial enzyme and that with this accomplished he would consider his mission completed. After the work on albumen had reached definite conclusions, Fischer took up a study of the depsides. These are ester-like anhydrides of phenolcarboxylic acids. He succeeded in preparing synthetic depsides which resembled those obtained from lichens. He also produced glucosides of aromatic polyoxy-acids, which were similar to tannin and which had marked tanning properties. One of these products, hepta-tribenzoyl-galloyl-*p*-iodo-phenyl maltosazone ($C_{220}H_{142}O_{58}N_4I_2$), molecular weight 4021, holds the record as the largest molecule ever produced by synthetic processes. This work was never finished.

In 1893 Fischer was elected to the Berlin Academy of Sciences and in 1895 he accomplished the great feat of inducing van't Hoff to become a member of the Berlin academic community. These two were united by ties of intimate friendship until van't Hoff's death in 1911, and Fischer was chosen to deliver his friend's eulogy before the Academy. A great number of students were attracted to Berlin by Fischer's accomplishments, and his personal energy was so infectious that the publications from his laboratory reached astounding proportions.

Fischer often suffered from insomnia and nervous complaints, and these increased to such an extent that he was forced to take a long vacation in 1903, but, as often before, the rest brought complete recovery and he took up his duties with renewed activity. He was the leading spirit in the Chemical Society. He took a prominent part in the development of the Kaiser Wilhelm Gesellschaft and the great research institution at

Dahlem is indebted to him in no small measure. The World War was a great sorrow to him and the death of his two younger sons in 1916, one by suicide, the other from typhus in a field hospital, almost broke his spirit. This depression was accentuated by the enormous expenditure of physical and mental energy which he devoted to war activities. He was one of the ninety-three who signed the famous manifesto in 1914, a protest to the cultured world against the reviling of German art and science, in which it was asserted that there was no connection between the "kultur" and the militarism of Germany. He later regretted this step and he was the leader of those who opposed removing Ramsay's name from the list of honorary members of the Chemischen Gesellschaft. He argued that this honor had come to Ramsay the scientist, and not to Ramsay the Englishman. In the summer of 1917 he had a severe intestinal attack which was diagnosed as paratyphus, and in 1918 he successfully recovered from an inflammation of the lungs. After a short rest at Locarno and Karlsbad, during which he wrote his autobiography, he returned to his experimental work and took up the direction of the laboratory with renewed vigor. On July 11, 1919, he was stricken quite suddenly, and the advanced stage of his intestinal disorder made a successful operation impossible. He died on July 15, in his sixty-seventh year.

His biographer Hoesch wrote: "Emil Fischer met a hard, terrible and unjust death. He, who had given so much to mankind, and who had desired for himself only a modicum of joy and pleasurable recollections; he, who had always been a loving, thankful and helpful son of this world, was dismissed from life heavily burdened in body and soul. From the midst of trouble and sorrow—his country vanquished, his science threatened, all those things at which he had toiled without stint, menaced—from such surroundings, death plucked him with a cruel hand. His life had no long evening of sunshine, of contemplative ease and pleasant meditation; the full-toned symphony of his life was sharply broken off by a harsh, hollow note of sorrow. What could be better calculated to make the belief in justice and reward on this earth an empty delusion, than Emil Fischer's death?" His body rests in the little cemetery at Wannsee. With his passing an almost incomparable fund of knowledge and experience was lost to the chemical world. His ability had so enriched our science that he will never be forgotten.

The purpose of science teaching in all grades of schools is not chiefly to impart knowledge of subject-matter but to train persons in the method of the masters, which is invariably the project method. This is the method used by intelligent men in achieving their ends, in school or out.—JOHN F. WOODHULL

MECHANICAL CHEMISTS

GUY BARTLETT, GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

The routine chemist—with his test tubes, retorts, delicate balances, and array of bottles covered with hieroglyphics—is being replaced in many manufacturing plants by different automatic devices for conducting analyses.

For instance, in one manufacturing plant there is an automatic electric signal which says, "Don't use that batch of copper. There's a little bit of iron in it somewhere; and, if you use it, it will spoil the brass." Whereupon the operator removes the 40-pound brick of scrap copper from the traveling table and consigns it to the pile of material which is destined for use in less particular work.

In another place there is a device which rings a warning gong. To the workmen the gong says, "There must be a leak somewhere in the mercury system, and you'd better check up on it. There's a slight trace of mercury vapor in the atmosphere—just about one part in a million—but it's dangerous." Whereupon the men see to it that plenty of fresh air is admitted to the room, and that the leak is found and repaired.

As still another example of the automatic chemist there is the x-ray diffraction apparatus which identifies different substances according to the pattern made on a photographic film when a capillary tube filled with the powdered substance is exposed to x-rays.[1]

Finding a Speck of Iron

In salvaging scrap metal such as copper, it is often necessary to determine whether there is iron in the scrap in such amounts that it would be spoiled for certain uses when melted down. The chemist could quickly determine the amount of iron after the scrap pieces had been melted down, but the analyses are needed previous to the melting. Bits of iron might be removed with a magnet, but such a procedure would mean that the scrap would need to be spread out loosely within the field of the magnet. The scrap is received as bits of tangled copper wire, compressed into bricks weighing about 40 pounds each.

The Federated Metals Corporation of St. Louis received a contract to supply high-grade copper for use in making cartridge brass, and in order to use the bricks of scrap copper it was necessary to make sure that the iron content was very low. Apparatus which detects iron in such quantities as 0.05 per cent in the 40-pound bricks was thereupon developed in the General Engineering Laboratory of the General Electric Company.

The apparatus consists of a table on which is mounted a hollow test coil,

[1] Reference was made to one of the numerous applications of x-ray diffraction apparatus in "Millionths of an Inch," THIS JOURNAL, **4**, 822–30 (July, 1927).

a platform on which the brick of scrap to be tested is placed, and a sensitive galvanometer relay which works in conjunction with a second relay to operate a signal system. A 40-volt storage battery supplies voltage for the test coil, relays, and signal system. The complete apparatus is shown in Fig. 1, with a brick of compressed copper wire resting on the platform, ready to be tested.

The details of the double-screw arrangement which moves the platform carrying the brick back and forth through the test coil at a rate of one foot per second are shown in Fig. 2. This double-screw arrangement, driven by a small induction motor, makes it unnecessary to reverse the

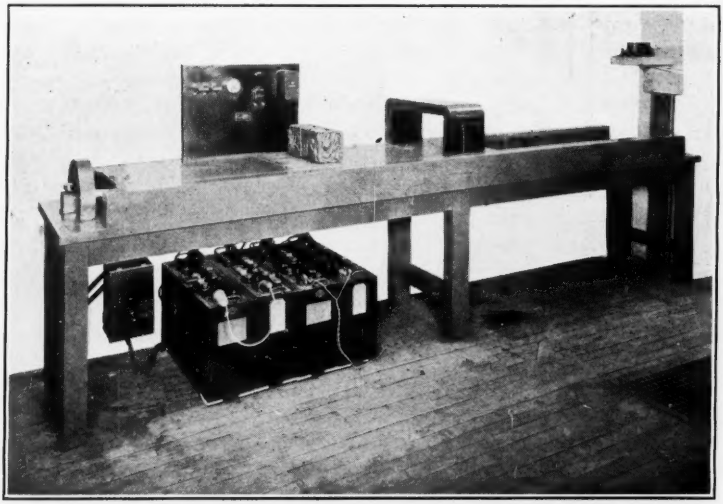


FIG. 1.—IRON DETECTOR. GENERAL VIEW FROM FRONT

motor each time the direction of travel of the platform is reversed. The platform travels back and forth automatically after the motor is started. On the panel, the rear view of which is shown in Fig. 3, are mounted a relay, signal buzzer and light, and an ammeter and triple-pole switch. The galvanometer is mounted separately so that it will be free from vibration. The wiring diagram of the device is shown in Fig. 4.

The bricks to be tested are placed, one at a time, on the platform when it is in front of the control panel. One operator, standing in front of the panel, can both place the bricks on the table and remove them; or a second operator, at the opposite end of the table, may remove the bricks after the test. Each brick must pass through the coil three times.

After each trip through the coil the brick is turned at right angles

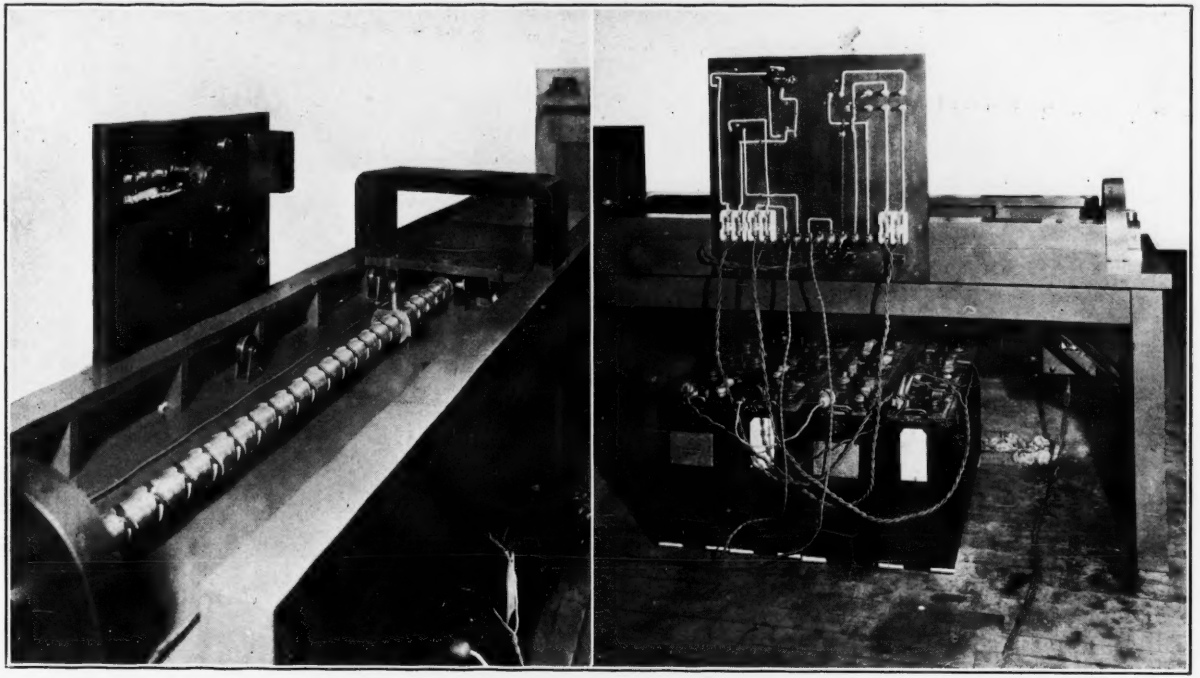


FIG. 2.—IRON DETECTOR. VIEW OF FEED SCREW FROM MOTOR END

FIG. 3.—IRON DETECTOR. BACK VIEW OF PANEL

to its previous position, so that all three dimensions of the brick are passed through the coil parallel with the axis of the coil. This is done so as to detect iron which may extend mostly in one direction with reference to the dimensions of the brick, since the impurity is most easily detected when passed through the coil in the direction of the longest dimension of the bit of iron.

The test coil consists of a primary and a secondary winding, with an air core. The primary is excited by a storage battery, giving a constant excitation at all times. Upon the passage of a piece of iron, such as might exist in one of the copper bricks, through the core, the flux threading the coil builds up to a higher value, and drops again to its previous value after the iron has passed beyond the core. When the brick of scrap copper is moved through the coil with a constant velocity, the variation of the flux is dependent upon the amount of iron present in the brick and on the direction in which the iron passes through the coil with reference to its longest dimension. This variation of the flux induces an electromotive force in the secondary of the coil. If enough iron is present (*i. e.*, above a certain percentage), an electromotive force of sufficient value will be produced in the secondary coil; and the galvanometer relay will be deflected and the contacts closed. This in turn completes the circuit to the secondary relay and the signal system.

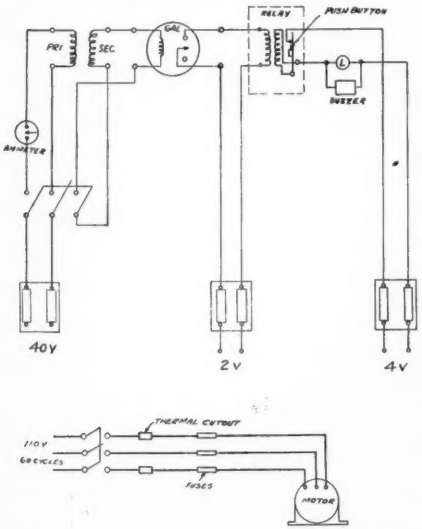


FIG. 4.—CONNECTION DIAGRAM (SCHEMATIC) IRON DETECTOR

After the brick has been passed through the coil three times it is removed, and another brick is placed on the platform. If a signal does not occur during the test, the brick is free from iron within the limits of 0.05 per cent, the value for which the apparatus is adjusted. The apparatus will easily test 50 bricks per hour.

Detecting Traces of Mercury

As small a proportion as one part of mercury in 20,000,000 parts of the atmosphere can be measured accurately by the mercury detector (Fig. 5)

which has been developed in the Research Laboratory of the General Electric Company; and one in 8,000,000 parts can be determined quickly as well as accurately.

Mercury poisoning is accumulative; it seems to make little if any difference whether the vapor is inhaled as relatively large amounts in a short period of time, or as slight amounts over a period of months. Because of the increased industrial use of mercury in heating operations in various chemical processes and in the newly developed mercury turbine,

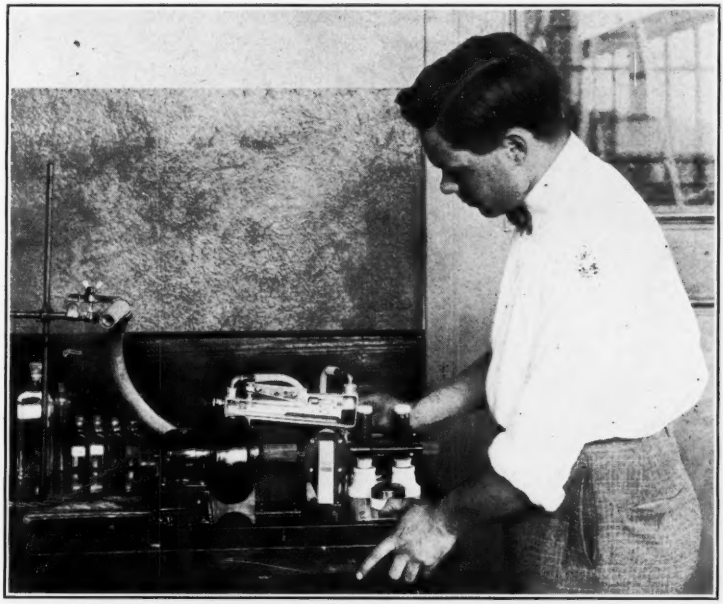


FIG. 5.—MERCURY DETECTOR FOR DETERMINING THE AMOUNT OF THE ELEMENT IN THE ATMOSPHERE

it has become important to have a method whereby leaks in apparatus and traces of mercury vapor in the atmosphere can be detected quickly.

Previous methods for determining the amount of mercury vapor in the atmosphere were tedious processes that required considerable time and the services of an expert chemist, and even then the results were usually far from accurate, especially when considering tiny amounts of the substance. The new method gives quick results, does not require the services of a trained chemist, and is accurate.

The principle on which the new method is based is a reaction between a solid substance, selenium sulfide, and the mercury vapor, with a

colored substance, easily observable with the eye, as the product of the reaction.

Yellow selenium sulfide is applied as a coating on paper. The paper is blackened on exposure to air containing mercury vapor, the degree of blackening depending on the concentration of the mercury, the time

FIG. 6.—AUTOMATIC MERCURY DETECTOR WITH CLOCK MOVEMENT FEEDING THE RECORDING TAPE

of exposure, and various other factors which can be definitely controlled. There seems to be practically no lower limit to the concentration that can be detected by this method.

For continuous and automatic registration of the mercury vapor, there has been devised a system in which a continuous strip of the coated paper is drawn slowly over an opening through which the air flows, a small clock motor moving the strip of paper at a uniform rate (Fig. 6). Within a short time after the exposure, the colored strip of paper can be compared

with a standard scale in which the different shades from yellow to black have been calibrated in terms of mercury concentration.

If an incandescent lamp is placed in front of the strip of paper and a photoelectric cell behind it, the amount of light reaching the cell will depend on the amount of blackening of the paper. The light can regulate the readings of an ammeter, so that the concentration of the mercury vapor can be determined either by observing the color of the paper or by reading an ammeter. It is also possible to so arrange the photoelectric cell circuit that a warning gong will be sounded if the mercury concentration becomes dangerously high.

AN EFFICIENT AND ECONOMICAL HYDROGEN SULFIDE GENERATOR

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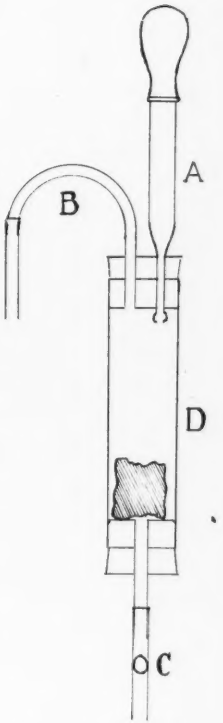
When compressed hydrogen sulfide is not available, the gas is usually supplied either from an apparatus such as a Parsons' generator or from Kipps. The use of either of these has its disadvantages, particularly with large classes. The individual gas generator suggested by the writer has been found, after a year's trial, both efficient and economical, besides eliminating delays which were unavoidable when the hydrogen sulfide was in constant demand. (See Fig.)

The acid is dropped in from *A*, while the gas escapes through *B*. The means by which the acid is supplied prevents an unnecessary excess being added. The waste liquor is removed by pinching the rubber tube on one side of the glass bead at *C*. *D* is a piece of glass tubing about seven-eighths of an inch in diameter and three inches long, and is fitted at both ends with rubber stoppers.



INDIVIDUAL H_2S GENERATOR

PASTEUR: THE CHEMIST

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We have just passed the glorious season of celebration of the birthday of one who served mankind in spiritual things, and great was that service, but it is not inappropriate to remind ourselves that the twenty-seventh day of December is also worthy of celebration by all humanity, for on that day there came into the world one whose achievements have ministered to the ills of the body as truly as the works of the Man of Galilee ministered to the spirit. This man was Louis Pasteur, the renowned French pathfinder in fields of chemical and biological investigations. His biological triumphs we shall leave for those better prepared to relate them; we shall turn to his contributions to chemistry, the science in which he was trained and for which he had a consuming passion.

Pasteur was a trained chemist, and it can be said without contradiction that his success in other scientific fields was due to his careful chemical training. Other sciences up to his time had dealt with superficial description and empty nomenclature largely, and it was Pasteur who brought to them the exact experimental methods and close reasoning of the chemist. Pasteur was an ingenious experimentalist but unlike many experimenters he was also possessed of a keen logical mind and an exceptional and vivid imagination. His penetrating insight into the unknown was, among all his fine qualities, probably the most significant. Experiment almost without fail proved his theories. Even to this very day, thirty-two years after his death, very little of Pasteur's work requires revision—a unique record.

Louis Pasteur was born December 27, 1822, at Dôle. Two years afterward his parents moved to Arbois where he passed his childhood. He began serious preparation for life at the College of Arbois. This institution, however, proved unsatisfactory to the young student because of the absence of a chair of philosophy. It was in the College of Besançon that he met and studied with M. Darlay whom he often much embarrassed with pointed questions which the teacher was unequal to answering. After graduating from Besançon he was ambitious for further study and determined to prepare for the Ecole Normale at Paris. This proved a wise choice for the young man, for here he came under the influence of Balard, the discoverer of bromine, and Dumas the renowned chemist who was then lecturing at the Sorbonne. Under Balard's instruction he made such decided progress in chemistry that upon graduating he was appointed an assistant to Balard. The Ecole furnished him another inspirational instructor in the person of Delafosse, the eminent crystallographer.

Following his student days he held several important appointments. He was first called to Strassburg, and later to Lille as professor of chem-

istry and Dean of the Faculty of Sciences. It was here that his real study of fermentation began. From this time on, 1854, Pasteur turned his attention more and more from the field of pure chemistry to that of applied chemistry—fermentation studies and biological problems of a chemical nature.

It is perfectly evident from this brief account of the early history of the man that his great interest was in chemistry and its applications. What wonder is it that Pasteur should be considered first of all a chemist. His enthusiasm for chemistry is indicated in a letter to his friend Chappuis in which he says: "Why are you not a professor of chemistry or physics? We should work together, and in ten years' time we would revolutionize chemistry. There are wonders hidden in crystallization, and, through it the innermost construction of substance will one day be revealed. If you come to Strassburg, you *shall* become a chemist; I shall talk to you of nothing but crystals."

Interest in Crystals

While a student at the Ecole Normale, Pasteur had been much impressed by his teacher, M. Delafosse, whose interest in crystal forms created in the young student such a profound spirit of investigation that upon the first opportunity he set out to repeat in great detail the work of M. de la Provostaye on the crystalline form of the tartrates. What a significant choice! Almost no other field would have proved so fruitful to the youthful investigator. Here it was that his successes began.

Crystal Studies before Pasteur

In order to view Pasteur's work in its setting it is necessary to briefly review the work of his predecessors and contemporaries. Very early in the study of crystal form Haüy had introduced the idea that the geometrical form of the crystal was the result of simply piling up "integral crystal molecules" one upon the other, and that the outward crystal form was governed by the form of the single "integral crystal" out of which the whole was built. In other words, geometrical regularity was an evidence of physical and chemical regularity.

This general notion was advanced by the introduction of the principle of isomorphism of Mitscherlich. In this principle we have the notion that chemical molecules of isomorphous substances are of the same type, which was an attempt again to relate crystal form with the constitution of the molecule, a relation more clearly expressed than the work of Haüy permitted.

M. Delafosse, whose pupil Pasteur became, added to the study the conception of irregularity among crystals and showed that the beautiful laws of form of Haüy were not always followed. While his work offered no

real advance in clearing up the difficulties of crystalline form, yet it emphasized to the mind the fact that the form of the "integral molecule" of the crystal is not so closely bound up with the crystal itself as Haüy had taught.

Double refraction of crystals was known to Newton and Huygens, and the phenomenon of polarization of light by crystals was discovered by Malus in 1808. Arago and Biot, pupils of Malus, extended the work of their master, and in 1815 Biot made the significant discovery that natural organic substances such as sugar, camphor, tartaric acid, oil of turpentine, etc., possess the power of rotating the plane of polarized light either when the substances are liquid or are in solution. As a result of his studies Biot pointed out the rather significant fact that these substances even after having lost their crystalline form were optically active, while other substances known to be optically active as crystals completely lost the property when the crystal was destroyed. As a conclusion of this discovery he pointed out the fact that rotatory power in organic substances must be due to the structure still remaining, namely, the molecule itself. As this discussion proceeds one will readily see how significant Biot's observation was. It forced the physical phenomenon of polarization into the very face of the chemist who now *must* take cognizance of it.

About this time Biot communicated to the Academy of Sciences a note by Mitscherlich wherein was contained the extremely interesting fact that the paratartrate and the tartrate of soda and ammonia were exactly alike in all physical properties save in the fact that the paratartrate exhibited no rotation to polarized light while the tartrate was active.

There can be no question that the work of Biot and this interesting observation of Mitscherlich were the deciding factors in causing Pasteur to undertake his first piece of independent research—the crystal structure of the tartrates.

Pasteur and the Tartrates

At the outset a very striking thing occurred. On the tartrate crystals Pasteur found small facets which had not been described before. Even the careful Delafosse had overlooked these slight irregularities in crystal form. But what of these facets? Why were they of any importance? It was in this fact; namely, that quartz crystals had been shown by Haüy to have right- and left-handed facets, and that the position of the facets, according to Sir John Herschel, determined the nature of the rotation. Only a step now for the enthusiastic Pasteur. Rotatory effect was due to the crystalline form. As he continued the work he found hemihedral faces, as these facets were called, on all the 19 different tartrates examined. The further fact was shown that these tartrates gave optical rotation coinciding with their hemihedrism. "This correlation related them to quartz

but had a deeper meaning, for here it could be no longer a question of the arrangement of the molecules in the crystals, but of arrangement of the atoms in the molecule." Pasteur was too well taught by Delafosse not to have laid strong hold upon this discovery of new facets on crystals whose solutions were active as a confirmation of the idea of a fundamental connection between hemihedrism and rotatory power.

The Paratartrates

Recalling the observation of Mitscherlich on the difference between the paratartrates and the tartrates of soda and ammonia in regard to optical rotation, Pasteur naturally examined the paratartrates in some detail. Here he found the same facets, but much to his surprise they occurred differently placed on some of the crystals, for some were turned toward the left, others toward the right. What could have been more natural for Pasteur than to separate these one from the other and test their solutions polarimetrically? A dramatic situation resulted. The left-handed crystals produced left-handed rotation and the right-handed were rotatory to the right. He had thus succeeded in resolving paratartaric acid into active enantiomorphs. These results were so startling that no one believed them. When they were communicated to Biot he refused to accept them until the experiments were performed under his direction and before his eyes. This Pasteur agreed to and his experiments were again successful. Biot was so moved by the result that he took the young investigator by the arm and said: "My dear child, I have loved science so much throughout my life that this makes my heart throb."

Instead of two tartaric acids there were now three. The dextro-acid, the hitherto unknown levo-acid, and the racemic acid. It was further found that when concentrated solutions of the dextro- and levo-acid were mixed in equal proportions there was an evolution of heat, and the crystals produced were identical with the original racemic form and also identical with those crystals produced at the factory of Thann, where they were first discovered and thought to be oxalic acid.

Pasteur was always given to coördinating and summarizing his work. Said he: "(1) When the elementary atoms of organic products are grouped asymmetrically, the crystalline form of the substance manifests the molecular asymmetry in non-superposable hemihedry. The cause of hemihedry is thus recognized. (2) The existence of the same molecular asymmetry betrays itself, in addition, by the optical rotatory property. The cause of rotatory polarization is likewise determined. (3) When the non-superposable molecular asymmetry is realized in opposite senses, as happened in the right and left tartaric acids and all their derivatives, the chemical properties of these identical and inverse substances are rigorously the same."

The following statement coupled with the above may be said to form the very foundation of stereochemistry: "All bodies fall into two great classes, bodies with superposable images and bodies with non-superposable images—bodies with asymmetric atomic arrangement and those with homohedral atomic arrangement."

Resolution of Racemoids

Having found that paratartaric acid was resolvable into active forms it was only natural for Pasteur to inquire whether other methods than the mechanical separation of right and left crystals might not be employed. Three other highly significant methods were developed. First, separation by crystallization; second, separation by the use of a suitable ferment; third, separation by the use of other optically active bodies.

The first method consisted in the production of crystallization from a saturated solution by seeding out the solution with crystals whose form the precipitate should take. This method has proved successful in resolving lactic acid into active forms (Purdie, *Trans. L. C. S.*, **1893,** 63), and Emil Fischer used it in resolving *d-l*-gluconic lactones into active forms (*Ber.*, **1892,** 25).

Pasteur came upon the second method as a result of his observation that under certain conditions tartrate solutions fermented. "Why not try the effect of the fermentation on the racemic acid?" thought he. Interestingly enough he found that certain ferments, particularly *Penicillium glaucum*, when allowed to grow in the racemate solution destroyed the dextro isomer and left the levo isomer unattacked. This bio-chemical method has proved of inestimable value in the separation of isomerides. Many different organisms have been employed upon a large number of substances with great success.

The third method developed has proved its usefulness in many important directions, particularly in Emil Fischer's work on the synthesis of the sugars, and in Ladenburg's work on the synthesis of the natural alkaloids. It was found that when certain optically active substances, *e. g.*, (1) quinine, strychnine, brucine, (2) cinconine, cinchonidine, morphine, etc., were brought into solution with the racemic form of the substance there were produced compounds with the alkaloids of sufficiently different solubility to result in a complete separation by crystallization. After precipitation of the dextro or levo form the active form was recovered by the destruction of the alkaloid. This method has proved singularly significant in many very important syntheses.

Transformation of Tartaric Acids

Upon heating dextro-tartaric acid either with water or in the form of its cinchonine salt he found that the dextro acid was partially transformed into

the levo acid, some racemic acid, and most important of all into an inactive tartaric acid which was not resolvable into racemoids by any method. In this he discovered a fourth kind of acid which is now familiarly called meso-tartaric acid. The significance of this discovery is made apparent by merely mentioning the fact that E. Fischer applied it in his sugar researches with brilliant success.

Malic and Aspartic Acids

Pasteur did not confine himself alone to the optical properties of the tartaric acids but directed his attention toward other active substances, *e. g.*, malic acid and its derivatives, and aspartic acid. Though not as successful in this field as he had been with the tartaric acids, some rather instructive disclosures were made in spite of the difficulties. M. Dessaignes was reported to have prepared aspartic acid by heating the ammonium salt of fumaric and maleic acids. Such a preparation as this was, of course, impossible to Pasteur. He was too firmly grounded in the notion that molecular asymmetry manifested in the optical rotation of substances was produced only by vital agencies to have accepted an aspartic acid from any other than the natural source. Upon careful study he proved that the product while identical in other respects with the natural acid was in truth inactive. He then converted the new aspartic acid into malic acid by the method of Piria and likewise proved this acid to be inactive. This proved to him the possibility of a fourth form of malic acid which was not racemic, neither dextro nor levo but, as he expressed it, "an asymmetric body so twisted that it becomes superposable on its mirror image." Of course Pasteur was wrong in assuming a fourth class here, still the idea of a possible fourth form due to some sort of internal compensation was a most important addition to the general theory of asymmetric compounds. So sure was he of the fourth type of substances that he assumed it for all asymmetric compounds, but of course he was in error, for we know that only those substances whose molecules can be divided into symmetrical halves by a suitable stereometric arrangement of the groups yield a possible fourth form.

Fermentation Studies

When Pasteur began his study of alcoholic fermentation it was the generally accepted belief that such a process was the result of dead yeast undergoing "postmortem decomposition." Such a conception could have no place with Pasteur for he had seen how asymmetric bodies were formed by vital processes and that fermentations were often associated with asymmetric bodies. Fermentation, therefore, must be the result of a vital process and not of the putrescence of a decaying body. He proved his point, as we so well know now. In this connection we owe to Pasteur the

honor of being the first to attack scientifically those problems in which both the chemical and biological aspects received their due share of consideration. He bridged the gulf between chemistry and biology, and made progress because he recognized the value of chemistry in the solution of biological problems. It was during his fermentation studies that he made the discovery of the possibility of life without air — anäerobic life.

Following the studies on alcoholic fermentation he began to make investigations on the vinegar process. He showed that the conversion of wine into vinegar is the work of a rod-like organism, which he called *mycoderma aceti*, and that in order for the process to be successful the mode of life of the organism must be understood. So thoroughly did he work out the details of acetic fermentation that he proved a great benefactor to the vinegar industries and in so doing convinced his opponents of the correctness of his views.

Conclusion

Louis Pasteur, the French chemist, has become the heritage of the scientific world and his work is his greatest monument. What more glorious and enduring monument could a scientist leave to commemorate his name than Pasteur has left: the foundation of the science of stereochemistry on which our modern organic chemistry rests; the groundwork of fermentation processes so important industrially today; the basis of modern bacteriology and pathology; the cornerstone of modern surgery; the veritable key-stone to the arch of immunity from disease! Humanity owes more than it can ever repay to this matchless man of intense passion and tremendous enthusiasm for constructive scientific research.

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ANOTHER ATTEMPT TO BASE A CLASSIFICATION OF THE ELEMENTS ON ATOMIC STRUCTURE

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It is believed that the student of chemistry is materially assisted in his reasoning when he has in mind some simple mechanical picture of the particular phenomenon in question. Not infrequently a picture deviating more or less from that called for by the newest discoveries and the most precise reasoning of experts is best suited to his needs. Thus in the study of certain chemical phenomena the cubical atom of Lewis may be more easily grasped and applied than the kinetic model of Bohr.

This consideration has been kept in mind in the preparation of the present paper and it is believed that at least the final figure will be of some value to the student in his attempt to gain an appreciation of some of the various properties associated with atomic structure and of the relation which the statistical atom bears to the actual atom.

It is the purpose of this paper to present a new basis for the classification of the elements. A certain group of elements, here called the zero group, is separated into three sub-divisions; most of the elements in this group have stable atomic configurations to which the architectures of the neutral atoms of the less stable elements revert as the latter change to charged atoms; that is, as they ionize. The remaining seven groups of elements are then also separated into sub-divisions according to which of these stable types of zero group architecture their atoms approach during ionization.

In Fig. 2 the elements are shown arranged in the order of their atomic numbers on the full line spiral; in Fig. 1 the same arrangement is presented in the conventional form. Here it is to be particularly noted that the present classification does not differ materially from the generally accepted form except for the questionable placing of the rare earths. This latter exception is not unique for it was employed by Rydberg, Hicks,[1] Parson,[2] and Langmuir.[3] The verging of the transition elements with the inert group becomes less shocking when one considers that the folding of almost any table of the elements to the form of a cylinder will give the same result.

Bury,[4] in his modification of the Langmuir atom, suggests for the atoms of the zero group elements the following structures: He (2), Ne (2,8), A (2,8,8), Kr (2,8,18,8), Xe (2,8,18,18,8), Nt (2,8,18,32,18,8),

[1] Hicks, *Phil. Mag. and Jour. of Science*, **28**, 139 (1914).
[2] Parson, *Smithsonian Miscellaneous Collections*, **65**, No. 11 (1915).
[3] Langmuir, *J. Am. Chem. Soc.*, **41**, 868 (1919).
[4] Bury, *Ibid.*, **43**, 1602 (1921).

Ni (2,8,16,2), Pd (2,8,18,16,2), Gd (2,8,18,25,8,3), Er (2,8,18,29,8,3), Pt (2,8,18,32,16,2).

Assuming with Bury that the first, second, third, and fourth shells are complete only when they contain respectively, 2,8,18, and 32 electrons, it is evident that among these elements the atoms of only helium (2) and neon (2,8) have all shells complete. These two elements constitute the zero, or numeral, division of the zero group.

It should be pointed out that, whereas Bury considers groups of 8 or 18 electrons in a layer as being stable regardless of the state of complete-

1 A	1 1	1 B	2 A	2 2	2 B	3 A	3 3	3 B	4 A	4 4	4 B	5 A	5 5	5 B	6 A	6 6	6 B	7 A	7 7	7 B			0 A	0 0	0 B
																			1 H					2 He	
	3 Li			4 Be			5 B			6 C			7 N			8 O			9 F					10 Ne	
	11 Na			12 Mg			13 Al			14 Si			15 P			16 S			17 Cl						18 A
		19 K			20 Ca			21 Sc			22 Ti			23 V			24 Cr			25 Mn	26 Fe	27 Co	28 Ni		
29 Cu			30 Zn			31 Ga			32 Ge			33 As			34 Se			35 Br						36 Kr
		37 Rb			38 Sr			39 Y			40 Zr			41 Cb			42 Mo			43 —	44 Ru	45 Rh	46 Pd		
47 Ag			48 Cd			49 In			50 Sn			51 Sb			52 Te			53 I						54 Xe
		55 Cs			56 Ba			57 La			58 Ce			59 Pr			60 Nd			61 Il	62 Sa	63 Eu	64 Gd		
65 Tb			66 Dy			67 Ho																			68 Er
		69 Tm			70 Yb			71 Lu			72 Hf			73 Ta			74 W			75 —	76 Os	77 Ir	78 Pt		
79 Au			80 Hg			81 Tl			82 Pb			83 Bi			84 Po			85 —						86 Nt	
		87 —			88 Ra			89 Ac			90 Th			91 Ur_2			92 U								

FIGURE 1

ness of the layer, a particular point is here being made of differentiating between merely stable groups and entirely completed shells.

The atoms of the elements argon, krypton, xenon, and niton have structures which are characterized by the presence of layers, all of which are stable but not all of which are complete. Thus in the case of krypton, Kr (2,8,18,8), the first three layers are complete; the fourth layer, however, which may contain 32 electrons, is not complete for it contains but 8 electrons. These four elements, together with erbium, constitute the B division of the zero group. The reason for placing erbium in this division will be given later.

The elements nickel, palladium, gadolinium and platinum, in their ordinary forms, have structures which are characterized by having, in

certain layers, numbers of electrons which represent unstable configurations. In consideration of what is to appear later in this paper it is necessary here to follow well-established precedent by postulating a rearrangement of the extra-nuclear electrons of the atoms of these elements and to recognize a stable β-form. Thus ordinary nickel, Ni (2,8,16,2), may be assumed to be capable of existing in the β form, Ni (2,8,18). These four elements make up the A division of the zero group.

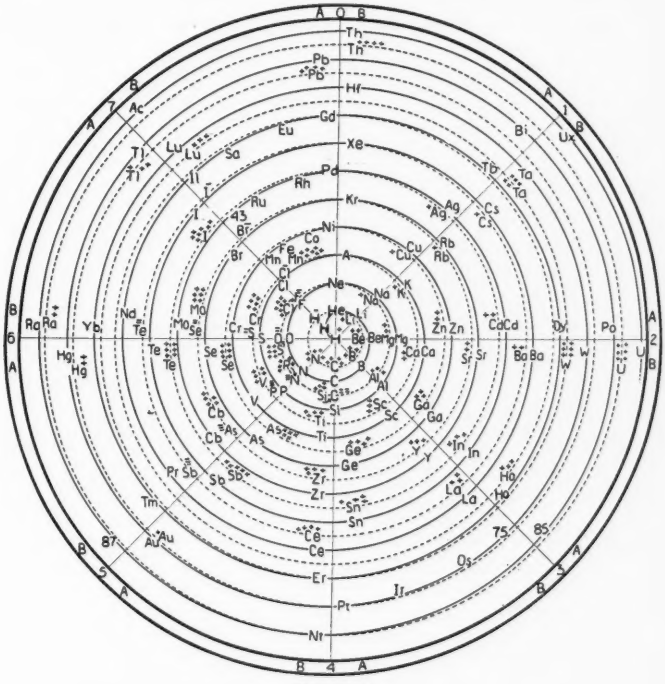


FIGURE 2

As a recapitulation, let it be stated that the zero group consists of elements among which three different types of atomic architecture are assumed; the group is, therefore, divided into three sub-divisions.

The discussion which follows will become more easily understandable if it is now pointed out that about the pole of the spiral (Fig. 2) and through each member of the zero group, there is seen to be described a broken-line circle; on these lines appear the symbols for the isosteric[5] forms of many of the elements whose atoms change during ionization so that

[5] Langmuir, *J. Ind. Eng. Chem.*, **12**, 368 (1920).

they have an extra-nuclear electronic arrangement similar to that of the particular zero group element through which the circle passes.

The zero group having been divided into three sub-divisions, the other seven groups may be divided also into A, B, and numeral sub-divisions in accordance with the arbitrarily defined principle that each element, in its own group, holds a position in the same division as is held in the zero group by the element with which it becomes isosteric as a positive ion.

Thus the arsenic atom, with the atomic number 33 and with the structure As (2,8,18,5), may be assumed to lose (or share) 5 electrons as the neutral atom changes to the positive ion As^{+++++} (2,8,18) which is isosteric with the β form of nickel. So As^{+++++} is placed on the isosteric circle which passes through nickel. Since the β form of nickel is classed as a member of the A division of the zero group, arsenic is classed as a member of the A division of the fifth group.

It is also true that the neutral arsenic atom may be assumed to gain three electrons forming the ions As^{---} (2,8,18,8), which is isosteric with krypton, Kr (2,8,18,8); As^{---} is, therefore, found on the isosteric circle passing through krypton. This classes As^{---} as a B division member of the fifth group; the neutral atom of arsenic, however, is to be placed in the A division, since we are here classifying the elements according to their positive ion reversion.

In this fashion each element in a group has its division determined.

There is a point relating to Fig. 2 which requires explanation. Among the zero group elements, from helium to gadolinium, the full line spiral goes through a complete revolution as it passes from one zero group element to the succeeding one. However, the zero group element following gadolinium is erbium, the spiral having passed through only one-half a revolution. This has the effect of reversing the zero group so that its members follow the order: He, Ne, A, Ni, Kr, Pd, Xe, Gd, then Er, Pt, and Nt.

This same reversal takes place with the members of the other groups. Accordingly Group 1, for instance, is located, lithium to terbium and thulium to 87. Fig. 1 shows the eight groups and their respective subdivisions in the conventional form.

The placing of erbium in the B division of the zero group, among the inert gases, also requires explanation.

Bury suggests for erbium the structure Er (2,8,18,29,8,3). Bury sees no chemical reason for assuming an alternate structure; however, if we may here suggest the highly stable but incomplete configuration Er (2,8,18,32,8) as an alternate form, a worthy representative of the zero group is at hand.

Also Langmuir,[6] in his modification and extension of the Lewis atomic

[6] Langmuir, *J. Am. Chem. Soc.*, **41**, 885 (1919).

theory, had in mind a highly symmetrical beta form of erbium. The items so far presented would, however, place erbium in the A division.

The determining reason for placing erbium in the B division of the zero group instead of in the A division is that if it were given the latter position, tantalum and tungsten, which revert to the erbium configuration, would then be classed with arsenic and selenium, respectively; this is not justified by experience.

Objectionable as is the highly speculative hypothesis relating to the so-called beta form of elements, it does help to account for certain phenomena. Thus neutral atoms of Cu, Zn, Ga, Ge, As and Se lose 1, 2, 3, 4, 5, and 6 electrons, respectively, to form stable ions—all with the same number of extra-nuclear electrons that is possessed by the neutral atom of nickel. Apparently, however, one must not be too exacting in his demands of the principle for bromine does not form a stable per-bromate and bismuth does not commonly form a penta-valent ion and many other flagrant exceptions are to be noted especially where certain quantum relationships are in the process of development.

The rare earth elements, here as in most of the other classifications, fail to fall in line perfectly. It is interesting, however, to note that the unusual properties of the rare earths appear to be a function of their relative position in Fig. 2, lying as they do on the borderland between relatively small atoms on the one hand and relatively large atoms on the other hand.

The usefulness of the principle here described may be extended by plotting a curve in such a way that the position held by each element corresponds not only to the element's atomic number but also to its atomic weight. This curve will extend into the third dimension and its vertical projection on a plane will be identical with that shown in Fig. 2.

To make this clear, consider the case of the first three elements. The atomic number of hydrogen is one. Hydrogen is, therefore, placed on a radial line one unit distant from the center as it is in Fig. 2. Its atomic weight is also one—that is, its total weight is represented by its excess nuclear positive charge; so its position remains unchanged.[7] The atomic number of helium is two. This fact places helium two units from the center on the next clock-wise radial line. But the atomic weight of helium is four; consequently, the final position of this element is on a line passing vertically through helium in Fig. 2 and two units below. Lithium's atomic number of three places this element three units from the center on the next clock-wise radial line as in Fig. 2. Its atomic weight, however, is 3.94 units more, so its final space-position is 3.94 units vertically below that which it has in Fig. 2.

[7] This is not strictly true for its weight is 1.008.

Fig. 3 is a photograph of such a curve built to scale. A lead shot marks the space-position not only of each simple element but also of each isotope of the pleiads.[8] An imaginary plane, carrying a spiral similar to Fig. 2, parallel to the base and passing through hydrogen (the uppermost element), and a blackened rod passing vertically through the center of the spirals serve as a plane and a pole of reference.

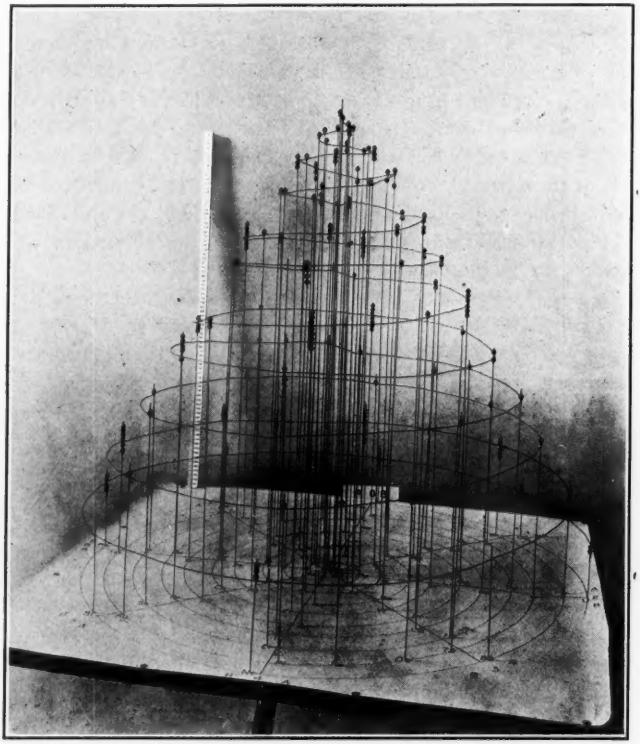


FIGURE 3

It is evident that the number of units distance from the pole of reference to each element in Fig. 3 corresponds both to the element's atomic number and to that portion of its atomic weight which is represented by its excess nuclear positive charge. Its vertical distance below the plane of reference passing through hydrogen corresponds to the remainder

[8] The relative masses of isotopes thought to be present in elements 81–92 are not definitely known.

of its weight or to its neutralized nuclear charge plus the extra-nuclear electronic mass. A scale for making these measurements is shown in the photograph. The results of isotopism, packing effect, inaccurate atomic weights, etc., are reflected in the irregularities of the conical helix which passes through the points plotted for all the elements.

Several points are peculiar to the classification of the elements here presented and to the principle involved. The "rogue" hydrogen has a place. The positively charged hydrogen ion has a particularly significant position if it is to be regarded as one of the building blocks of which all of the elements are constructed. The negatively charged hydrogen ion also has a place. A high degree of symmetry obtains throughout in Fig. 2. Although the Bury modification of the Langmuir atomic models has been used almost exclusively in this paper, the principle may be extended to other atomic models. Thus the Bohr[9] atomic models can be interpreted so as to yield a very similar classification while the Langmuir[10] models lead to a different result.

Summary

It has been pointed out that a particularly significant classification of the elements results from a consideration of their atomic structure when one recognizes different types of architecture among the atoms of the zero group elements to whose stable configurations the less stable elements revert as isosteric substances during the act of ionization. A space-curve is also described which permits consideration separately of the atomic number of an element and of the factors which go to make up the mass of its atoms. The position of hydrogen and of the rare earths is of particular interest.

[9] Bohr, *Nature*, **112**, 29 (1923).

[10] *J. Am. Chem. Soc.*, **41**, 868 (1919) and *Rept. Brit. Assoc. Adv. Sci.*, **1921**, 468–72.

Dried Egg Whites Produce Curious Disease in Rats. Interesting new facts about food keep coming to light from research in nutrition. Dried whites of eggs when included in the diet of rats produce a curious new type of disease, Dr. Margaret A. Boas of the Lister Institute has found.

"After 2 or 3 weeks, red scaly patches appear at the corners of the animal's mouth, the coat becomes rough and sticky, and the long hairs fall out. The red patches then spread, and the baldness increases. There are also nervous symptoms. In all cases the rats lose weight progressively and soon die, although rats on the same diet but with fresh instead of dried egg-white live quite contentedly in perfect health."

Dr. Boas does not consider that the disease is caused by a toxic substance but believes that it is due to the deficiency of some essential food factor which is probably destroyed when the egg white is dried. The dried egg white can be rendered quite harmless, she has found, by adding some other substances to the diet, such as potatoes or arrowroot.—*Science Service*

THE NEW LABORATORIES OF THE BRUSSELS POLYTECHNIC SCHOOL

FERNAND LAMBERMONT, ENGINEER A. I. G., BRUSSELS, BELGIUM. TRANSLATED BY COLIN MACKENZIE MACKALL, GEORGE WASHINGTON UNIVERSITY, WASHINGTON, D. C.

The Departments of Pure and of Applied Science took possession of the new buildings of the University of Brussels in October, 1924. As America took such a large part in the establishment of the present University it is natural to give a description of the new equipment in THIS JOURNAL. In this article we will pass over the general architecture of the buildings, which have not yet been completed, and describe not only the chemical laboratories and those for the teaching of chemistry, but also some other laboratories which are interesting because of modern features they present.

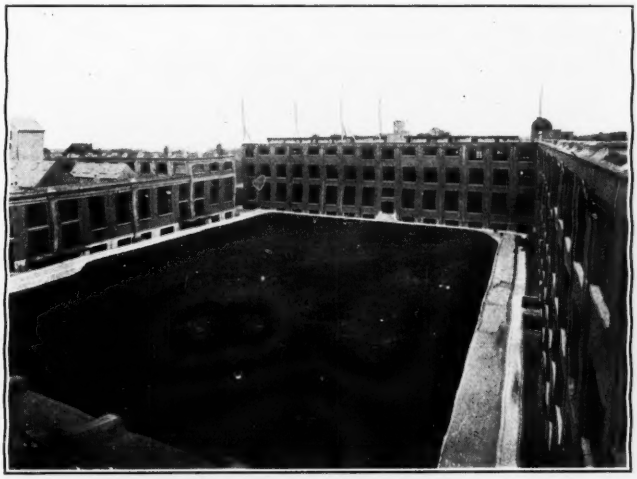
The new buildings cover 7.9 acres. The principal part of the building, five stories in height, is devoted to pharmacy, zoölogy, botany, mineralogy, astronomy, mathematics, and analytical mechanics. The double wings are given up, in general, to the principal chemical laboratories. The laboratories for mechanics, hydraulics, and the study of materials are located in a separate building between the inside wings of the main building. The frame-work of the buildings has been constructed of reinforced concrete. The large interior court provides for future enlargement.

The principal aim of these new laboratories in the Solbosch quarter of Brussels is the application of a reörganization in engineering education consisting essentially in the development of experimental studies. Our friend, Mr. Nony-Hénault, the distinguished professor and director of the laboratories of general and industrial chemistry, has clearly stated the nature of this reform in an article which appeared in a special bulletin of the *Revue de l'Ecole Polytechnique de Bruxelles* for November, **1924.** His remarks, moreover, apply in general to university instruction in Belgium.

Until recently, the chemical studies of the future Belgian engineers were followed in common by the students of the Department of Pure Science and by those of the Department of Applied Science. This arrangement necessarily placed a very heavy load upon the professor in charge of the course, and consequently prevented him from orienting his course in chemistry as completely as possible toward the special objective of the engineering students. Today, the separation has been made. I hasten to say that the promoters of this reorganization have never had the idea of imposing a purely empirical or professional character upon the teaching of chemistry in the engineering curricula. On the contrary, they have wished to preserve its profoundly scientific character, seeking only to distribute the burdens which appear at the very beginning of this instruction, leaving the less pressing problems for solution later on. This was indispensable, for the reorganization is dedicated to the predominance of experimental instruction in scientific method, and this result could be attained only on condition that the present curriculum be curtailed in part and limits placed upon oral instruction. Thus it has appeared to be necessary to reduce the instruction in organic chemistry to the barest essentials, ad-

vanced work in industrial organic chemistry being reserved for those students planning to enter the chemical industries. If necessary, a knowledge of pure organic chemistry may be obtained in the courses and existing laboratories devoted to the preparation of candidates for the doctor's degree where instruction in this branch of chemistry is highly developed.

This discerning article indicates the orientation of chemical engineering studies, as they were until recent years; too many general courses, insufficient laboratory practice, assimilation in one or two years of all the elements of physics and chemistry, and an incomplete preparation of the chemical engineer for practice in the industries. The studies of the chemical engineer in Belgium have generally been understood as being a



VIEW OF THE INTERIOR COURT

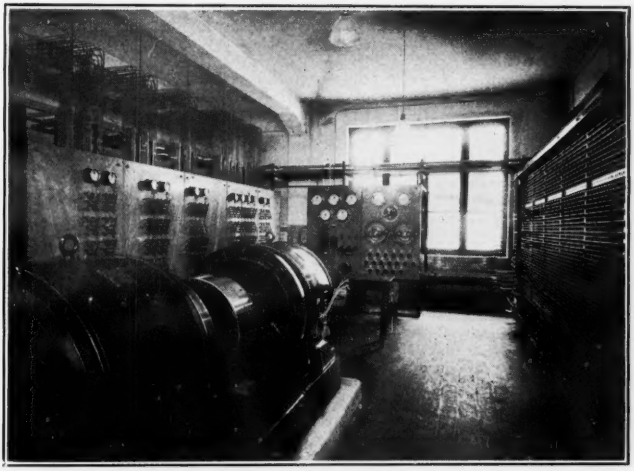
simple compromise between two curricula, a compromise effected by combining an abbreviated curriculum in chemistry with shortened curricula in mining, or in industrial engineering. The laboratories existing in the new University are evidence that this condition will no longer exist, and that the instruction in chemistry will consist in real specialization made possible by the new installations.

There are two large laboratories for forty students, with a separate balance room. They are directly connected with those of the laboratory instructors and those for special work. A well-ventilated basement contains rooms for experiments in industrial chemistry, arranged for temporary installation of apparatus. The electrochemical and electrothermic apparatus can be supplied by either continuous, single phase, or

A LABORATORY OF GENERAL CHEMISTRY

polyphase current. The neighboring rooms provide for mechanical preparation (such as grinding, sifting, etc.), gas analysis, calorimetry, and electrochemistry. Several laboratories are reserved for permanent or temporary collaborators; three of these rooms are reserved for the study of the physical chemistry of colloids.

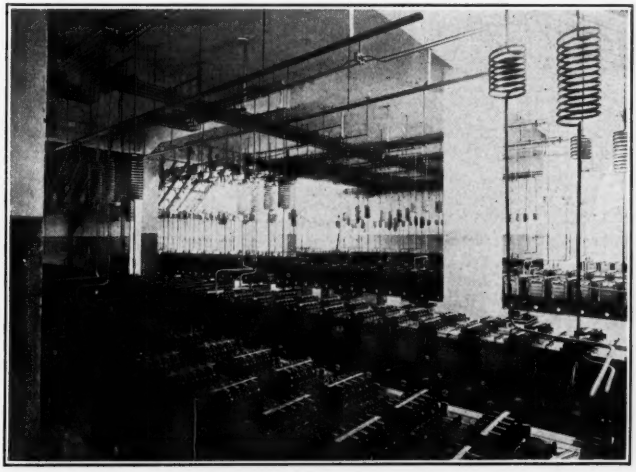
A CHEMICAL LECTURE ROOM



A Part of the Central Power Plant

The large chemistry lecture room is particularly bright and commodious. Its equipment allows the professor to carry out important and unusual experiments during the lecture.

The special laboratories of analytical chemistry arranged in an analo-



Storage Battery Room

gous manner, are large enough for fifty-six students to work there at the same time. They connect with the metallographic laboratories.

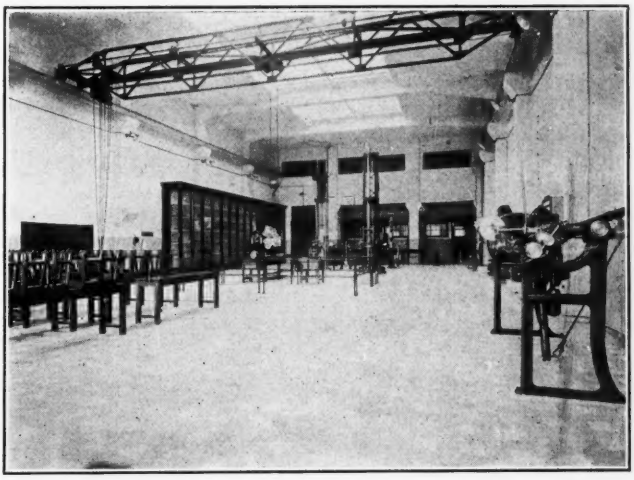
The laboratories of electrical engineering and electrical measurements, and of physics and chemistry are fed current supplied by the central power plant of the University, which presents the novel feature of being connected to the high tension line of the City of Brussels independently of its own generators in such a way that its transformer works in parallel with the panel receiving the current from the city. Thus the University consumes the current of the city or supplies it to the city depending upon whether it uses more or less than the current furnished it by its own trans-

LABORATORY OF ELECTRICITY AND ELECTRICAL ENGINEERING

former working constantly at full capacity. In addition there are storage cells of a capacity of 3500 ampere-hours.

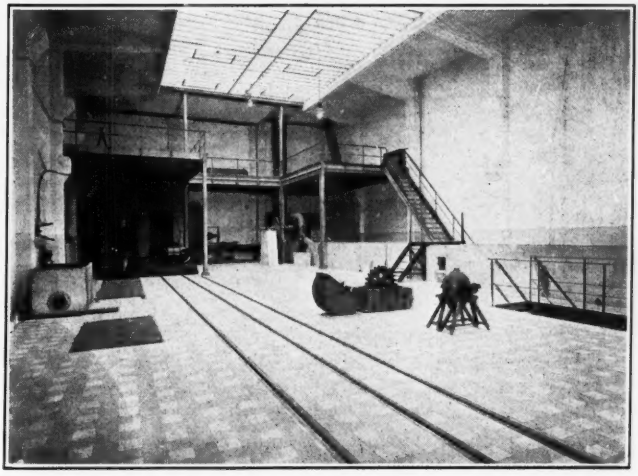
As we have said, the University of Brussels has substituted for the conventional laboratory of stereotyped demonstrations the laboratory of research and study. We have seen how this dominant idea of the reorganization has been put into effect in the chemical laboratories. One finds the same spirit of efficiency in the laboratories of electricity and electrical engineering which are well arranged for individual work and for work with groups of students.

The laboratories for the testing of materials form an important part in the new organization. They permit a technical study of materials; mechanical, metallographic, and chemical tests. The principal mechanical testing apparatus is placed in a large, well-lighted room supplied with a



LABORATORY FOR THE RESISTANCE OF MATERIALS

two-ton rolling bridge. At hand are small laboratories for chemistry, metallography, photography, and the preparation of samples. A small lecture room, with lantern, is provided so that at any time a group of fifty students may be shown slides illustrating the remarks made by the



A VIEW OF THE MECHANICAL LABORATORIES

professor or his assistant in the laboratory. Besides these laboratories, the Department of Material Testing has another small group forming the laboratory of photo-elasticity, the first of its kind in Belgium.

Let us note in conclusion the fine mechanical laboratories, the photograph of which shows their present condition. They are connected with the hydraulics laboratory, not yet completed, which is planned for research in hydro-mechanics.

Finally, let us return to the instruction in chemistry. The course in general chemistry has a physico-chemical character more and more pronounced, accompanied with laboratoy work during forty-five afternoons.

MICROSCOPICAL LABORATORY

As Professor Dony-Hénault has said, in distributing the work of general chemistry over the first two years of the course a real advantage has been obtained, as is shown clearly by the results of the examinations up to this time. In the last years, the preparation of the students is such that it fits them better to enter into the industries as thoughtful and specialized engineers.

The more specialized, the better oriented, in our opinion. Personally I know of paradoxical cases which are astonishing. I will mention only two of them. Among my fellow students one graduated with the degree of Engineer of Bridges and Highways; at present he is director of a gelatine factory. Another received the degree of Chemical and Electrical Engineer; since then he has been occupied with reinforced concrete. One must recognize that these cases, of which I could cite many, bear witness

to an unjustified confidence in the method of training an engineer in a non-specialized course.

The reorganization which we have rapidly outlined bears the seal of an unquestionable unity. The University of Brussels, in its new installations, has wishes to bring about a reorganization in the higher technical training of which the essential elements are the laboratories. It is interesting to note that they have cost tens of millions of francs due to private initiative. One must acknowledge the part played by the professorial staff of the University of Brussels which has carried out this tremendous task with resources which were initially quite modest.

At the present moment, dormitories for men and for women students are being built. A veritable university city is being constructed at the gates of Brussels. Let us hope that many American students may come to join the thousands of Belgian students who will reside there. They will receive a most cordial welcome, and upon returning to their own country, they can tell of the admirable results obtained by the University of Brussels in its new laboratories.

The photographs which illustrate this article were obtained through the kindness of M. Charles Chargois, professor in the University of Brussels and President of University Extension, to whom the author makes grateful acknowledgment.

Metallized Insects Made by New German Process. Insects made of metal, true to the originals in the last minute details of structure, are produced by a process discovered by Dr. N. D. Zelinsky, a German chemist. As a matter of fact, the insects themselves are metallized through a replacement of their original substance with the metal, just as the details of wood or leaf structure are replaced with stone in petrifactions.

The process was discovered by a quasi-accident. Dr. Zelinsky had undertaken to make chemical analysis of some insects. The procedure involved covering them with finely powdered copper oxide and heating them in small platinum crucibles under an atmosphere of carbon dioxide. At the end of the treatment he found to his astonishment that he had a collection of perfect copper insects, for the outer part of their body-shells had been penetrated by the metal and the original horny chitin, with all its fine markings, was replaced by a layer of copper.

It is thought that this method may be of value in museums in the permanent preservation of rare and perishable specimens, and possibly plants as well. There is also the possibility that a vogue in natural jewelry may be based upon it.—*Science Service*

New Kaiser Wilhelm Institute to Study Internal Medicine. Medical men and chemists will work together to make an intensive study of the effect of medicines on the human body at a new research institution for internal medicine to be established by the Kaiser Wilhelm Society at Heidelberg, according to the German correspondent of the American Chemical Society.

Prominent among the investigators who will work on the staff of the new institution is Prof. L. Krehl of Heidelberg University, well-known specialist in internal medicine.—*Science Service*

A SYSTEM FOR TEACHING THE SUBSTITUTION OF RADICALS IN ORGANIC COMPOUNDS

I. W. WADE, NEW YORK UNIVERSITY, NEW YORK CITY

The author has frequently noticed the inability of students, after a year in organic chemistry, to recall the methods of preparing a given class of substances by substitution. The principles underlying the substitution of radicals, occurring as they do in isolated divisions of the average text, do not give the student enough tangible work upon which to build a working knowledge of the theories. With this in mind, the author prepared the following system and has used it with his classes with noticeable success.

Basic Principles of the System

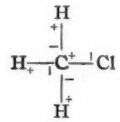
At the beginning of the course in organic chemistry, the attention of the student is called to the method of making methyl iodide from methyl alcohol. The reaction is represented by the equation

$$CH_3OH + HI \longrightarrow CH_3I + H_2O$$

The transition from the known to the unknown is easily made by the student, for in general chemistry negative groups are usually found replacing negative groups. But when the reaction between methane and chlorine gas is studied, the reasoning of the student does not hold without additional explanation. Here a negative chlorine atom replaces a positive hydrogen according to the equation

$$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$$

At this point an intensive study is made of the recent theories of atomic structure in relation to valence. The work of Stark and of Moseley is reviewed, but emphasis is placed on the theories of Bohr[1] and Lewis-Langmuir.[2] After reviewing the rôle of the electron in highly polar compounds like sodium chloride and in relatively non-polar compounds like diatomic hydrogen, the student is prepared to accept the following graphic representation of the valence charges in a molecule of methyl chloride:



[1] Bohr, *Phil. Mag.*, XXVI, **1**, 476, 857 (1913).

[2] Lewis, G. N., "Valence and the Structure of Atoms and Molecules," The Chemical Catalog Company, New York, **1923.**

Lewis, *J. Am. Chem. Soc.*, **38,** 762 (1916).

Langmuir, *Ibid.*, **41,** 868 (1919).

The students are then shown atomic models of carbon and of chlorine atoms, thus acquiring through another sense organ tangible evidence representing the changes that take place in substitution. Reference is

SUBSTITUTION of RADICALS IN ORGANIC COMPOUNDS

	H	Cl	Br	I	OH	COOH	CN	NH_2	NO_2	R
H	1	2	3	4	5	6	7	8	9	10
Cl	11	12	13	14	15	16	17	18	19	20
Br	21	22	23	24	25	26	27	28	29	30
I	31	32	33	34	35	36	37	38	39	40
OH	41	42	43	44	45	46	47	48	49	50
COOH	51	52	53	54	55	56	57	58	59	60
CN	61	62	63	64	65	66	67	68	69	70
NH_2	71	72	73	74	75	76	77	78	79	80
NO_2	81	82	83	84	85	86	87	88	89	90
R	91	92	93	94	95	96	97	98	99	100

FIGURE 1

This chart should be at least 3 × 3 feet and should hang on the class-room wall.

frequently made to the original papers of Stieglitz, L. W. Jones, W. A. Noyes, H. S. Fry, J. Stark, Falk and Nelson, and others.

Material for the System

At the beginning of the second week all students are asked to supply themselves with 100 plain white filing cards. (The instructor should see that the book store carries an ample supply of cards of the size 3 in. × 5 in., perfectly cut.) The chart in Fig. 1 is then shown and a sample card is made out according to Fig. 2.

In both the vertical and horizontal column the chart has the same

groups (R represents an alkyl radical, usually CH_3^- or $C_2H_5^-$). The groups in the vertical column are to be replaced by the groups in the horizontal column. The squares are numbered and a card is made for each square. Where like columns cross, *i. e.*, squares 1, 12, 23, etc., the card bearing the same number then carries the analytical test for the group, *i. e.*, H, Cl, Br, etc., respectively.

Use of the System

Taking for an example an assignment on the saturated alcohols, the students are required to bring to class, cards bearing the methods of preparation indicated in squares numbering 5, 15, 25, etc., vertically down the column to number 95; and cards bearing the chemical reactions of the alcohols on cards 41, 42, 43, etc. It can easily be seen that the students must by necessity take recourse to books other than the text in order

TO REPLACE Cl BY OH: 15

1. $C_2H_5Cl + KOH \rightarrow C_2H_5OH + KCl$
Noyes: Organic Chemistry. p 60.

2. $\begin{matrix} COOH \\ CHCl \\ COOH \end{matrix} + AgOH \rightarrow \begin{matrix} COOH \\ CHOH \\ COOH \end{matrix}$
Chamberlain: Organic Chemistry. p 296.

FIGURE 2

to fill the required cards. Even after a thorough search in standard references there will yet remain a few cards, such as numbers 65, 85, and 95 in the preparation group, and numbers 47, 48, and 49 in the reaction group that will be confusing and incomplete. These cards excite a fine questioning attitude on the part of the student. This attitude is wholesome and is augmented each day by the narrowing search for the reactions or preparations which will ultimately complete the chart. The cards are checked by the instructor after each class period and returned to the students at the next meeting.

In this manner the important classes of aliphatic and aromatic organic compounds are studied. For the latter class of compounds, the same chart is used, but the cards are reversed and the card number now goes to the upper *right*-hand corner to facilitate quick reference. The emphasis exerted by this system in the class-room bears fruit in the laboratory where the majority of experiments deal with standard methods of preparation and the reactions of typical members. The analytical test

cards referred to above are found invaluable for reference and for confirming the substitution products of the compounds prepared in the laboratory.

Advantages of the System

This method of studying the preparations and reactions of the carbon compounds offers the instructor:

1. A well-organized and smooth-running plan for teaching the fundamental principles of substitution of radicals.
2. A system which points out profitable lines for future study and research by holding up to the attention seemingly impossible reactions and in suggesting other methods as well. (It was surprising to the author how often students came to him with an idea for a new and unusual preparation or reaction. These ideas were given to the advanced students and projects were developed to test the truth of the idea.)

This method offers to the student:

1. A basis for the study and review of the principles governing substitution.
2. A revelation of the vastness of organic chemistry and of the amount of work yet to be done in standardizing preparations and in controlling reactions, especially those due to steric influences in the aromatic hydrocarbons.[3]
3. A definite outline for all laboratory work.
4. An introductory familiarity with the literature of organic and physical chemistry.

The disadvantages of the system lie in its scope rather than in its principle. The size of the chart limits the representation of radicals with the result that such groups as SO_2OH, SH, NO, COR, and others must be left out for special consideration. It is at once evident, also, that radicals with a normal valence of two or three, etc., do not work well with this system.

[3] Brown and Gibson, *Trans. Chem. Soc.*, **61**, 367 (1892).
Stieglitz, *J. Am. Chem. Soc.*, **44**, 1299 (1922).
Porter, C. W., "The Carbon Compounds," Ginn and Company, New York, **1926**, revised edition.

In order that the facts obtained by observation and experiment may be capable of being used in furtherance of our exact and solid knowledge, they must be apprehended and analyzed according to some conceptions which, applied for this purpose, give distinct and definite results, such as can be steadily taken hold of, and reasoned from.—W. WHEWELL

THE RELATION BETWEEN THE DEGREE OF INTELLIGENCE AND SUCCESS IN THE STUDY OF CHEMISTRY*

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This study was initiated with the desire to determine how accurately one could predict the success of a pupil in the study of chemistry solely upon the basis of a general intelligence test.

Tests and Measures Employed

The literature concerning intelligence tests has been abundant during the last few years, and it was felt that one of the best means of estimating the value of one of these tests was to determine its ability to predict the degree of success a pupil might attain in high-school chemistry. Or to view this analysis from a different angle, considering the intelligence test as the constant, the aim was to determine how closely various achievement tests bore out its findings. Nor should the point of view be neglected that the comparison between general intelligence and achievement tests often gives an opportunity to focus the attention of teachers and supervisors on the type of pupil who possesses the mentality to succeed if he only had the desire. Of course, it must be admitted that intelligence tests are designed to measure native mental ability and not achievement, and they should not be considered in error if they do not correlate well with specific achievement results. Thus a general intelligence test at best can be only a guide when the aim is to make it measure success in a specific subject.

On the other hand, the selection of a standard of success in chemistry was a most important consideration. Of course, one of the best indications of success in the mastery of the subject is teachers' marks. Similar to teachers' marks, though not so searching, especially as to the attitude the pupil takes, are the results of the Regents' examination—an examination given by the New York State Board of Regents to all pupils of the state who have had, in the case of chemistry, a year's course.

In addition, in the last few years a few achievement tests have been devised for high-school chemistry, and up to the time that this study was begun, two of these tests (Rich's and Powers') were well known to the writer and considered worthy of being used to evaluate success. These achievement tests are designed to measure the results of a pupil's attempt to master this definite field of knowledge. In other words, they aim to measure success in the study of chemistry. Thus all four achievement measures mentioned were employed in this investigation and were com-

* A digest of a thesis submitted in partial fulfilment of the requirements for the degree of Master of Arts in the School of Education, New York University.

pared with one standard intelligence test, namely, the Terman Group Test of Mental Ability, Form A.

Description of Data

Concerning the Rich chemistry tests, the Manual of Directions[1] says in part:

> They are designed to provide for the measurement by objective methods of the attainment of groups of individuals on the following phases of its results of instructions in chemistry: (*a*) ability to think; (*b*) information; (*c*) ability to solve numerical problems; (*d*) habits and knowledge acquired from work in the laboratory. The material chosen for testing purposes is drawn from the range of items found in five representative texts, twenty-five recent examinations given by the College Entrance Examination Board and by the Regents of the University of the State of New York and from a number of state syllabi on chemistry. Within these limitations only items have been chosen which have relevance to at least one of the seven social aims of education as laid down by the N. E. A. in 1918. The indications from this series of tests will not agree closely with the results of examinations such as those of the regents in New York State. The examinations set by such bodies include a considerably larger proportion of pure memory work than do these tests.

The following is quoted from the Manual of Directions of the Powers' General Chemistry Test, Form A.[2]

> There are two parts to the test. Part 1 is a test of range of information. Part 2 tests ability to write formulas and equations, to give the chemical names of common substances and to do simple calculations. Items were selected which were common to most high-school textbooks in chemistry and which chemistry teachers were emphasizing in their courses. More than sixty schools from all sections of the country coöperated in this work. Where there is a marked disagreement between the teacher's judgment of a student's ability and his score on the test the teacher may well question whether his judgment is correct.

Conditions under Which Scores Were Obtained

All the tests were given in June, 1925; and teachers' marks were those of the period from February to June, 1925.

The same Regents' examinations were given to all pupils concerned, and were scored in each school, as is usual in New York City, by all members of the department. Each teacher is given certain problems to score. Any pupil's paper, the mark of which is below the passing grade (65) is reviewed at least once in the hope of passing the pupil. All pupils are required to take the Regents' examination, though the writer is not certain that this requirement is strictly enforced. Finally, the papers are sent up to Albany and are subject to the review of the Regents.

A number of pupils who took the tests had to be eliminated because

[1] S. G. Rich, "Rich's Chemistry Tests Manual," Public School Publishing Co., 1923.

[2] S. R. Powers, "Powers' General Chemistry Test," World Book Co., 1924.

one or another of the tests had not been taken, due, most likely, to absence. This investigation represents scores from four High schools in New York City, namely, Boys, Erasmus, Manual Training, and Morris. The total number of pupils, both boys and girls, whose scores are included in this thesis, were 189, divided into groups of 61, 50, 61, and 17, respectively, in the order mentioned above. There were seven teachers' marks included, two from each of the first three schools mentioned and one from the last.

It should be noted that all the pupils of one school and three from another, 64 in all, had taken three semesters of chemistry while all the others had taken two. Full consideration was given to the effect of these pupils upon the combined scores in the Terman, Powers, and Rich Tests. However, scores of two- and three-semester pupils were found to be not appreciably different and are not reported here.

Final Scores

In order to compare the Terman Test scores with the combined scores of the other four tests, it was assumed that the abilities dealt with, that is, the ability to score in the various tests, and the ability registered by the teachers' marks were distributed according to the normal probability curve, and upon this basis the percentile rank of each pupil was obtained in the Terman Test and in each achievement result. All percentile ranks were then transmuted into quantitative equivalents and a composite score, produced by adding the four achievement quantitative equivalents and dividing by four, was then capable of being correlated with the Terman Test scores.

The teachers' marks presented an additional difficulty, due to the fact that they represented the ratings of seven teachers. It is unlikely that the same mark given by all the seven teachers would be of equal value. Therefore, the percentile rank of each pupil in his own class was obtained, and this rank was then converted into a quantitative equivalent.

The question may arise as to how fairly this group of 189 pupils represents the general run of pupils who have completed one year of chemistry. In order that this phase can be properly reviewed, three tables are inserted, the first showing quartile ranges of the raw scores, the second showing the authors' norms for various tests, and the third comparing the authors' standard deviations for their tests with those of the present study.

Incidentally, one standard deviation when laid off on each side of the average includes, approximately, the middle two-thirds of the distribution. Therefore, the smaller the value of the standard deviation in any given test, the more homogeneous will be the group.

Tables I and II reveal that the group under consideration is somewhat superior to those groups used as norms by the authors of the Rich and

Powers Tests, and decidedly superior to those used in the Terman Test. Table III shows that these pupils also constituted a more homogeneous group than those used by the authors of the tests.

The superiority is accounted for by the fact that these pupils come from a large city in a section of the country where the standard of scholarship and teaching is higher than the average for the country at large, where

TABLE I

QUARTILE RANGES OF THE RAW SCORES FOR ALL RATINGS EXCEPT THOSE OF THE INSTRUCTORS

	Lowest	Second	Third	Highest
Powers	21–34	35–39	40–44	45–65
Rich	28–50	52–55	57.5–65	65.5–90
Regents	40–70	71–77	78–85	86–98
Terman	88–151	152–171	172–187	188–212

TABLE II

AUTHORS' NORMS FOR VARIOUS TESTS

Powers	Upper Quartile norm one-year chemistry pupils	46
	Median norm one-year chemistry pupils	36
	Lower Quartile norm one-year chemistry pupils	26
Rich	Highest Score for one-year chemistry pupils	83.0
	Mean for one-year chemistry pupils	53.3†
	Lowest Score for one-year chemistry pupils	28.0
Terman	Upper Quartile norm for 12th-grade pupils	169
	Median norm for 12th-grade pupils	147
	Lower Quartile norm for 12th-grade pupils	122

† Rich gives no median. The Rich Test mean of the present study is 54.2.

TABLE III

STANDARD DEVIATIONS FOR THE TERMAN, POWERS, AND RICH SCORES

Present study		Authors' report	
σ Terman	26	σ Terman	37
σ Powers	7	σ Powers	14.8
σ Rich	9.5	σ Rich	None reported

the norms have been obtained. The homogeneity of these pupils appears quite natural when it is remembered that the present pupils are all from one city, subject to the training of teachers who are controlled and selected by the Board of Education, and influenced by the syllabus of the State Board of Regents.

At the same time the Regents' quartiles throw some light on the grasp that the teachers have of the Regents' requirements, when the median score of all pupils is 77 and a pupil must receive 86 to have a place in

the upper quartile; whereas the lower quartile includes all those pupils whose marks range between 40 and 70.

While no definite statement can be made as to the significance of a given coefficient of correlation it is worthy to note that Miller,[3] in discussing the various standards for a good test for high-school students, says: "It should give a coefficient of correlation of 0.50 or higher with average school marks and with estimates of intelligence by teachers."

McCall[4] asks the following question: "Is an '*r*' of 0.30 high or low?" and answers it thus: "With *r*'s as with intelligence, or wealth, or beauty, the customary criterion is that of relativity. There seems to be a sort of rough agreement among workers in this field that when *r* is

0 to ± 0.4 correlation is low, or
± 0.4 to ± 0.7 correlation is substantial
± 0.7 to 1.0 correlation is high."

With these statements in mind we can proceed to Table IV, bearing in mind that equal in importance to the highness or lowness of a correlation is its reliability, dependent upon the size of the correlation and the number of pupils.

TABLE IV

WEIGHTED SCORE INTERCORRELATIONS INCLUDING PROBABLE ERRORS

	Powers	Rich	Instructors	Regents	Composite
Terman	0.45±0.04	0.49±0.04	0.26±0.05	0.31±0.04	0.48±0.04
Powers		0.58±0.03	0.58±0.03	0.60±0.03	0.84±0.01
Rich			0.35±0.04	0.43±0.04	0.75±0.02
Instructors				0.76±0.02	0.81±0.02
Regents					0.86±0.01

The following findings from Table IV are reported:

1. The Terman Test is least valuable in predicting success in chemistry when that success is based upon instructors' marks. It is slightly more valuable when Regents' marks are the basis for success, and somewhat more valuable when the Powers, Composite, and Rich correlations are considered. The Rich Test shows the highest correlation with the Terman Test.

2. The Terman Test shows the poorest series of correlations of any in the table.

3. When comparing the two achievement tests it is seen that the Powers Test correlates better than the Rich with all other results excepting the Terman Test. This was just as Rich anticipated as was noted in his manual.

It appears from these findings that the colleges might do well to use the

[3] Miller, W. S., "The Administrative Use of Mental Tests," National Society for the Study of Education, 21st Year Book.

[4] McCall, W. A., "How to Measure in Education," Macmillan Co., 1922, p. 392.

Powers Test in place of their college entrance examinations in chemistry because the memory questions bulk so largely in both.

4. The correlations between instructors' marks and the other tests are so nearly equal to the correlations between Regents' marks and the others that whatever conclusions may be drawn in regard to one may equally well be drawn about the other.

5. The composite correlations indicate that the four achievement results do not differ widely as measures of success in the study of chemistry as it is now taught. The Regents' correlations should be given first place, closely followed by the Powers Test.

Hardly less important than the preceding tables is Table V which shows the percentage of pupils grouped in quartile ranges of the Terman Test who received median scores or over in the various tests. In order that this table may be understood, the lowest quartile range in the Terman Test will be considered. Of the 50 pupils who constitute this group, 30% (15) received a median score or over in the Powers Test; only 14% (7) received a median score or over in the Rich Test, etc.

TABLE V

PERCENTAGE OF PUPILS GROUPED IN QUARTILE RANGES OF THE TERMAN GROUP TEST WHO RECEIVED MEDIAN SCORES OR OVER IN THE VARIOUS TESTS

Terman Group (Ranges)	Powers	Rich	Instructors	Regents	Composite
88–151 (50)*	30%	14%	52%	42%	36%†
152–171 (46)	54%	48%	44%	44%	48%
172–187 (48)	50%	56%	52%	52%	52%
188–212 (45)	76%	76%	69%	69%	76%

* Numbers in parentheses indicate number of pupils in range.

† Instructors' and Composite percentages represent pupils whose quantitative equivalents were 50 or above.

In Table V a few facts are worthy of note, namely:

1. It is evident that a pupil whose placement is in the highest quartile of the Terman Test will, approximately three times out of four, rate above the median in achievement as determined by any one of the four achievement results.

2. As far as those pupils are concerned whose marks are in the second and third quartile ranges of the Terman Test, they have about an equal chance of obtaining a mark which is either above or below the median in any achievement result.

3. In the lowest quartile of the Terman Test, the greatest divergence appears. In this group only a mere fraction (14%) received a median score or over in the Rich Test; whereas, more than twice as many in the Powers Test, three times as many in the Regents' examination and almost four times as many in the instructors' marks received a median score or over.

It will be remembered that the instructors' scores showed the poorest correlation with the Terman Test of all the achievement results and it is probable that in this grouping can be found the cause. Of the fifty pupils who came within the lowest quartile in the Terman Test, twenty-five were from one school. Fifteen of these twenty-five were considered as above the median by their instructors. That their estimates were not borne out by the three other achievement results is realized when it is noted that of the forty-five scores obtained from the three remaining achievement results by these fifteen pupils, only thirteen (29%) were median marks or over, and thirty-two (71%) were below the median. This school is thus responsible for the very low correlations between the Terman Test and teachers' estimates, and in a smaller measure has resulted in a lowering of the composite correlation with the Terman Test.

Summary of Conclusions

The following conclusions may be reasonably drawn upon the basis of the data presented:

Primary Conclusions

1. A pupil's general intelligence as indicated by the Terman Test is far from a certain indication of his future success, as judged by any of the four standards here set up; therefore, no effort should be made to force a pupil to relinquish his right to study chemistry if such is his wish.

2. A pupil whose placement is in the lowest quartile in the Terman Test has so little chance of obtaining an achievement result equal even to the median that if his Terman mark were to be considered in conjunction with the marks which he received in other subjects in high school prior to the study of chemistry, they would quite likely presage his failure in the present type of chemistry course. If this is so, then the proper advice to offer is that he take a more popularized and simplified chemistry course composed of different subject-matter. By no means should this latter course be forced on the pupil, but rather it should be offered as one in which the pupil would not alone have a better chance of success but in which he would also find more interest and profit.

Secondary Conclusions

1. The Terman Test is least valuable in predicting success in the study of chemistry when success is based upon instructors' marks.

2. The Terman Test is most valuable in predicting success when success is based upon the Rich Test results.

3. The Powers Test correlates better than does the Rich Test with the instructors', Regents', and Composite results.

4. Instructors follow so closely Regents' requirements, that often their marks can scarcely be considered as separate findings.

5. The Composite correlations indicate that the four achievement results do not differ widely as measures of success in the study of chemistry as taught at present.

6. A pupil whose placement is in the highest quartile range in the Terman Test will approximately, three times out of four, rate above the median in achievement as determined by any one of the four achievement results.

7. A pupil whose placement is in the second or third quartile ranges of the Terman Test has about an equal chance of obtaining a mark which is above or below the median in any achievement result.

8. The achievement results of pupils who studied chemistry for three semesters are not materially different from those of two-semester pupils.

9. The fact that large numbers of boys who are distinctly below normal succeed in passing Regents' examinations, raises the question as to whether these examinations are not too easy. These Regents' examinations are used as selective instruments. Graduation from high school does not depend upon passing Regents' examinations, but admission to higher institutions of learning sometimes does. Hence, it is possible to defend the maintenance of an absolute standard of achievement.

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QUALITATIVE ANALYSIS IN HIGH-SCHOOL CHEMISTRY

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The value of qualitative analysis as a cultural study was admirably presented in an article in THIS JOURNAL for March, **1927,** by Mr. Edgar J. Witzemann[1] and all who read this article should preface it by a careful reading of the above.

One of the fundamental objects of high-school chemistry is to give the pupil a type of mental training that is not brought out in any other subject, namely, to develop the power of reasoning and to apply it to actual and practical matters. It is a known fact that qualitative analysis gives this type of training in fullest measure but the ordinary course in the subject is usually not heard of or encountered unless a student desires to make a more or less complete study of chemistry after he enters college or university. This group seems a pitifully small minority to have the opportunity of enjoying the benefits of such a mind-training and reason-sharpening experience. It is the purpose of this short article to show how the subject can be used in the general high-school chemistry course and to relate some of the experiences and methods used by the writer in presenting the subject.

True, some texts have been prepared for a course to be given as an additional subject but few students have the time or desire to go farther than the one-year course and for most schools it is unprofitable to offer such a course. The writer attempted to present a bird's-eye view of the subject in two weeks and the results were very gratifying and interesting.

The best time for this work to come is toward the end of the course when the study of the metals has been completed. The work consisted in:

1. Studying reactions of the metals and dividing them into groups.
2. Preparing charts and trying the tests.
3. Analyzing unknowns.

Twelve metals were selected and divided into four groups, Group 1, metals precipitated as chlorides, Hg^{I}, Pb, and Ag. Group 2, metals precipitated as sulfides, Zn, Fe^{III}, and Cu. Group 3, metals precipitated as carbonates, Ca, Mg, and Al. Group 4, metals not precipitated by ordinary reagents, Na, K, and NH_4. The twelve metals chosen were common ones that had been studied so that the students were more or less familiar with their chemical properties.

The first laboratory period the students worked out their chart for the first two groups from information found in their texts and former experiments and additional information from the instructor. They then tried the tests and did one simple unknown. The following period the same

[1] THIS JOURNAL, **4,** 355–8 (March, 1927).

thing was done for the last two groups. Much better work is done by the students if they work out their charts.

The charts were then printed on cardboard outside of class and with many of the students, interest was aroused to such a pitch that some of the charts were veritable works of art. The charts were then corrected and the two laboratory periods of the following week were given to the solving of unknowns and here the writer was very much interested in just how much the students would be able to do. Each student was required to do, first, two simple unknowns consisting of single salts and after this one of a mixture of two salts and, finally, one of a mixture of three salts. The unknowns were given out as dry salts (either the nitrates or chlorides of the metals) in little packets. All four were numbered and given out at once. If a student reported incorrectly he must repeat his analysis and do another for penalty. This rule was made to eliminate guess-work and comparison.

The results were highly satisfactory. In two classes of fifty-two pupils all but six completed their work in the allotted time and all of the six finished by coming in after school. This was not compulsory, but they all wished to complete their work and regarded it as an interesting game of wits and skill rather than an irksome task.

Several boys made themselves a nuisance by getting their work done before the time was up and many students asked if they might do extra work in spare periods, so interested were they in the subject.

Qualitative analysis courses for the high-school student may be varied considerably, more metals may be used and the acid ions may also be studied, depending upon the length of time and the amount of work that the teacher wants to spend on the subject. The following is an example of a scheme used by the writer in a four-period or two-week course.

Metal	Group test	Individual test
Group 1	Add 10 cc. HCl	*Pb* Pour 10 cc. hot H_2O repeatedly through ppt.
Pb	White ppt. HgCl, $PbCl_2$, AgCl	$PbCl_2$ dissolves in *hot* H_2O, but crystallizes out when cool
Hg^{I}	Filter ppt. and save filtrate	*Hg* Pour 5 cc. NH_4OH over precipitate and catch filtrate. If ppt. turns black, Hg
Ag		*Ag* To filtrate add HCl; white ppt.—Ag
Group 2	To filtrate from above add 15 cc. H_2S sol.	*Zn* ZnS is the only white sulfide. Do not confuse with colloidal sulfur. Confirmatory test. Heat on charcoal with blow pipe. Yellow color while hot, white, while cold—Zn
Zn	White ppt. ZnS	
Fe^{III}	Black ppt. Fe_2S_3 CuS	*Fe* To a portion of the group 1 filtrate add 5 cc. NH_4OH, reddish brown ppt.—Fe
Cu		*Cu* White ppt. sol. in excess NH_4OH; bright blue color with above test—Cu

Group 3	To filtrate from above add 10 cc. Na_2CO_3	*Ca* To portion of filtrate from group 2 add 5 cc. $(NH_4)_2C_2O_4$—white ppt.—Ca
Ca	White ppt. $CaCO_3$, $MgCO_3$, $Al_2(CO_3)_2$	*Mg* To portion of filtrate add 5 cc. NaH_2PO_4; white ppt.—Mg
Mg		*Al* To portion of filtrate add 5 cc. NH_4OH, gelatinous ppt.—Al. Confirmatory test. Filter and transfer ppt. to charcoal block. Moisten with $Co(NO_3)_2$ sol. and heat with blowpipe; blue color—Al
Al		
Group 4		
Na	No ppt. with above reagents	*Na* To fresh portion of sample give flame test; yellow flame—Na
K		*K* Flame test—violet flame invisible through cobalt glass
NH_4		*NH_4* To fresh portion of sample add 5 cc. NaOH and warm; ammonia smell—NH_4

This chart is far from being flawless and a few directions and additions are necessary. The hydrogen sulfide solution had to be made alkaline with ammonium hydroxide to cause the zinc to precipitate. This in turn would cause aluminum in group 3 to precipitate. This can be explained to the students and the difference between zinc sulfide and aluminum hydroxide is easily discernible. Other minor troubles were encountered but none caused difficulty.

As was stated before this is only a bird's-eye view of the subject and our bird cannot be a buzzard when we consider the fact that we are dealing with high-school students and the scheme has been worked out chiefly from their own information. If simplicity were sacrificed for detailed accuracy perhaps the harm would be greater than the good in this case.

Probably entirely different and better schemes than this one can be devised but this article is not written with that point in view but only to show the value and practicability of qualitative analysis to the high-school student. In no part of the course did the students become so keenly interested, work so diligently, or derive so much benefit as in this work and the writer feels sure that his experiences will be duplicated by any other teachers of high-school chemistry who will give their students a taste of qualitative analysis.

We are gifted with the power of imagination, and by this power we can enlighten the darkness which surrounds the world of the senses. Bounded and conditioned by co-operant reason, imagination becomes the mightiest instrument of the physical discoverer.—J. TYNDALL

A MODIFIED PROCEDURE FOR THE ANALYSIS OF GROUP III*

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It has been the experience of those teaching qualitative analysis, that the beginning student has a great deal of difficulty in separating and identifying the ions of Group III. In a previous paper[1] the data obtained showed that zinc, aluminum, and chromium were correctly reported in less than eighty per cent of the unknowns in which they occurred, and that aluminum was incorrectly reported by more than ten per cent of the students. The precipitation of manganese as the carbonate along with the hydroxides of iron, aluminum, and chromium immediately after their separation from cobalt and nickel sulfides seemed to offer a means of making the test for zinc more reliable. Since the zinc is left in a solution containing only possible traces of nickel and cobalt ions it should be more easily detected and identified. This procedure also eliminates the boiling of a solution of sodium aluminate, sodium zincate, and sodium chromate to decompose the excess of sodium peroxide used in oxidizing the chromic, ferrous, and manganous ions; for our experiments show that a very large excess of sodium hydroxide must be added to prevent the loss of the zinc ion by the decomposition of sodium zincate into zinc oxide[2] as no provision is made for testing for zinc in the precipitate of ferric hydroxide and hydrated manganese dioxide. By this procedure, also, the chromium can be precipitated as the characteristic yellow lead chromate, a test which is far more satisfactory and less subject to complications than the formation of barium chromate.

Group III is precipitated in the ordinary way. The cobalt and nickel sulfides are separated from the other ions of Group III by the addition of 1 *N* hydrochloric acid, and quickly filtered to prevent the acid from reacting with the cobalt and nickel sulfides. The nickel and cobalt sulfides are dissolved by treating them with 5 ml. of concentrated hydrochloric acid, boiling the mixture and then adding concentrated nitric acid drop by drop until the granular precipitate disappears. The solution is again boiled to remove any nitric oxides or chlorine and to cause the free sulfur to collect into a globule. The solution is made ammoniacal and a slight excess of acetic acid is added. The cobalt and nickel ions are then tested for, respectively, by means of *alpha*-nitroso-*beta*-naphthol in an acetic acid solution and dimethylglyoxime in an ammoniacal solution.

The hydrochloric acid solution from which the cobalt and nickel sulfides

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[1] Heisig, THIS JOURNAL, 3, 177–88 (1926).

[2] See also Prescott and Johnson, "Qualitative Chemical Analysis," D. van Nostrand Co., New York, 7th edition, p. 185.

were separated is boiled to remove the hydrogen sulfide and 1 ml. of concentrated nitric acid is added to oxidize the ferrous ion. The solution is again boiled and then made alkaline to litmus with ammonium hydroxide. Ten milliliters of ammonium carbonate solution (1 *N*) are added to precipitate manganous carbonate and the mixture is again heated to boiling. The hydroxides of iron, aluminum, and chromium are precipitated with manganese carbonate, leaving the zinc in solution as a complex ammonio ion. The physical characteristics of this precipitate make it much more easily filtered than that of the hydroxides of aluminum, iron, and chromium usually obtained.

This precipitate is dissolved in a slight excess of dilute hydrochloric acid, an excess of sodium hydroxide is added, and, after cooling, solid sodium peroxide is sprinkled into the mixture. The excess of sodium peroxide is decomposed by boiling the solution to prevent the formation of perchromic acid when the solution is acidified with nitric acid. The manganese precipitates with the $Fe(OH)_3$ as $MnO(OH)_2$ and $MnO(OH)$. The ferric hydroxide is dissolved and is separated from the manganese oxides by adding 10 ml. of concentrated nitric acid. A part of the manganese oxides will also dissolve and can be reprecipitated as MnO_2 by boiling the solution after the addition of solid potassium chlorate. The presence of manganese in the precipitate is confirmed by the green color of the sodium manganate produced in a sodium carbonate bead which has been heated in the oxidizing region of a flame from a Bunsen burner with or without the addition of a small amount of potassium chlorate. The ferric nitrate is separated from the manganese dioxide precipitate and the iron is reprecipitated as ferric hydroxide by means of an excess of ammonium hydroxide. The quantity of the precipitate is noted and compared with that obtained from a "known" solution in order to distinguish between the trace that is nearly always present in the reagents and the minimum amount put into an "unknown."

The alkaline solution containing aluminum and chromium is acidified with nitric acid and a slight excess of ammonium hydroxide is added to precipitate the aluminum hydroxide. The presence of aluminum in the precipitate is confirmed by the aurin tricarboxylate test[3] which is carried out as follows: A portion of the precipitate is dissolved in 5 ml. of *N* HCl, 8 ml. of 2 *N* ammonium acetate, and 3 ml. of a 0.5 per cent solution of the ammonium salt of aurin tricarboxylic acid are added. When the contents of the tube are thoroughly mixed, an insoluble red lake will be formed. If, when the mixture is made alkaline with ammonium hydroxide and 1 ml. of a 1 *N* solution of ammonium carbonate is added the bright red precipitate persists, the presence of the aluminum is confirmed. This test will enable one to say with certainty whether the

[3] See also *J. Am. Chem. Soc.*, **48**, 1604 (1926).

TABLE I

SCHEME FOR THE ANALYSIS OF GROUP III

<table>
<tr><td colspan="5">Precipitate: $CoS, NiS, ZnS, MnS, FeS, Al(OH)_3, Cr(OH)_3$. Transfer to a beaker. Add 25cc. 1 N. HCl.</td></tr>
<tr><td rowspan="5">Residue: CoS, NiS. Add HCl and HNO_3. Boil. Remove S. Neutralize with NH_4OH Acidify with HOAc. Divide in 3 parts. Test one for Ni with dimethyl-glyoxime, another for Co with nitroso β-naphthol.</td><td colspan="4">Filtrate: $ZnCl_2, MnCl_2, FeCl_2, AlCl_3, CrCl_3$. Boil off H_2S. Add 4 drops conc. HNO_3 to oxidize Fe^{++}. Add NH_4OH until alk. to litmus, then add $(NH_4)_2CO_3$, and heat to boiling. Filter.</td></tr>
<tr><td colspan="3">Precipitate: $MnCO_3, Fe(OH)_3, Al(OH)_3, Cr(OH)_3$. Dissolve in dil. HCl. Make soln. slightly alk. to litmus with NaOH. Add a slight excess of Na_2O_2. Boil to decompose excess. Filter.</td><td rowspan="4">Filtrate: $Zn(NH_3)_6^{++}$ Make acid to litmus with HOAc. Pass in H_2S. Precipitate: ZnS</td></tr>
<tr><td colspan="2">Precipitate: $MnO(OH)_2, Fe(OH)_3$ Treat with 10cc. conc. HNO_3. Boil and add $KClO_3$ in 0.5g. portions until precipitation is complete.</td><td>Filtrate: $NaAlO_2, Na_2CrO_4$ Add HNO_3 in excess, then NH_4OH until alk. to litmus.</td></tr>
<tr><td>Precipitate: MnO_2 Confirm by Na_2CO_3 bead test.</td><td>Filtrate: $Fe(NO_3)_3$ Add xs. NH_4OH. Ppt.: $Fe(OH)_3$. Note quantity.</td><td>Ppt: $Al(OH)_3$ Note quantity. Confirm by $Co(AlO_2)_2$ or aurintricarboxylate test</td><td>Filtrate: Na_2CrO_4. Add NH_4OAc and xs. of HOAc. Add $Pb(OAc)_2$. Yellow ppt: $PbCrO_4$. If white ppt. forms, add NH_4OAc</td></tr>
</table>

precipitate presumed to be aluminum hydroxide contains any aluminum but it does not enable one to differentiate between a trace and a large amount of aluminum hydroxide. This information is best obtained by comparing the amount of precipitate presumed to be aluminum hydroxide with that obtained by the analysis of an equal volume of a "known solution."

To the ammoniacal solution of the chromate ion, a large crystal of sodium or ammonium acetate, an excess of acetic acid, and a few drops of lead acetate are added. A yellow precipitate of lead chromate will form. If a white precipitate is obtained, it is basic lead acetate, resulting from an insufficient quantity of acetic acid and acetates. The basic salt can be converted to soluble lead acetate by adding another larger crystal of the acetate and more acetic acid.

To detect the zinc ion, the complex ammonio ion is broken up with acetic acid and zinc sulfide is precipitated with hydrogen sulfide. If traces of cobalt and nickel ions are present, their dark sulfides will form more slowly than the white zinc sulfide. Hence zinc can be recognized in the presence of traces of cobalt and nickel ions. The procedure is given in diagrammatic form in Table I.

This procedure was tested by a graduate student before being used by beginning students in qualitative analysis. The unknowns used contained 500 mg. of ions (aluminum ion 75 mg.) and 0.5 mg. or 1 mg. of the ion whose detection was being attempted. If a satisfactory test for the ions was obtained, a + sign is placed in the proper column in Table II. The tests for 1 milligram of Co^{++}, Mn^{++}, Al^{+++}, and Cr^{+++} were so satisfactory that it was considered unnecessary to test for the presence of 0.5 mg.

TABLE II

	1.0 mg.	0.5 mg.
Co^{++}	+	
Ni^{++}	+	+
Fe^{++}	+	+
Mn^{++}	+	
Al^{+++}	+	
Cr^{+++}	+	
Zn^{++}	+	+

The procedure, after having been proved satisfactory in the hands of a graduate student, was used by two classes each having approximately ninety students, who are taking the elementary course in qualitative analysis in the fall quarter, and by all students taking qualitative analysis in the spring quarter. However, only the results obtained by the senior writer's classes in the analysis of unknowns containing the ions of Group III were tabulated. A comparison of the results obtained in the fall by two classes using this procedure with the average obtained by a number

of classes using the old procedure during a period of years is given in Table III.

TABLE III

COMPARISON OF RESULTS WITH THE AVERAGE VALUES 1923–25

	Times occurred	Times tested for	% Correctly reported 1926	Average % correctly reported	% Incorrectly reported 1926	Average % incorrectly reported
Ni^{++}	103	360	96.2	94.8	3.1	5.7
Co^{++}	101	360	91.0	90.1	1.5	2.4
Zn^{++}	111	360	82.0	77.5	7.1	9.3
Mn^{++}	67	360	86.6	81.7	3.3	2.8
Fe^{++}	81	360	84.0	86.1	9.9	12.0
Cr^{+++}	112	360	92.0	74.1	3.1	2.2
Al^{+++}	95	360	83.2	71.3	7.1	14.5

The percentage of students who correctly reported an ion has been designated "Per Cent Correctly Reported" while the per cent of students not correctly reporting an ion who incorrectly reported its presence has been designated "Per Cent Incorrectly Reported."

From the table it can be seen that the number of students correctly reporting zinc was increased 5% and the number incorrectly reporting this ion decreased 2%. This is a distinct improvement but is not nearly so striking as the results obtained with chromium and aluminum. The number of students correctly reporting the chromium was increased 18% and the aluminum 12%. The chromium incorrectly reported increased the negligible amount of 1% but the aluminum is distinctly better with a decrease of 7%. From data previously recorded it was concluded that if an ion was correctly reported 80% of the time, the procedure could be considered satisfactory. By this new procedure zinc, chromium, and aluminum ions are brought into the satisfactory group. The manganese which was correctly reported 81.7% in former years has been bettered five per cent. The marked improvement of the chromium ion is due, no doubt, to the lead chromate test in the presence of a high concentration of acetate ion, and that of the aluminum ion is due to the exclusive use of the aurin tricarboxylate test. The 2% loss in the per cent correctly reporting iron was due entirely to one class. Iron was correctly reported by all students in the other class.

A more exact comparison of the results obtained by using the two procedures may be made by comparing two sections of similar students under the same instructor during two different years. The classes in both years consisted chiefly of premedics and predents who were taking the course because it was required; consequently, their work would not be above average, and not at all superior as one would expect to be the case if they were taking the work on their own initiative. The two years selected are 1923 and 1926—the former because data on the subject was

available for that year. The classes were approximately the same size, numbering 81 and 78 students, respectively.

TABLE IV

A COMPARISON OF CLASS A, 1926, WITH CLASS A, 1923

	% Correctly reported 1926	% Correctly reported 1923	% Incorrectly reported 1926	% Incorrectly reported 1923
Ni^{++}	97.5	97.4	4.2	5.6
Co^{++}	95.0	76.2	1.6	2.0
Zn^{++}	83.5	81.2	8.8	5.7
Mn^{++}	90.5	75.3	4.3	7.1
Fe^{++}	100.0	90.0	14.8	7.0
Cr^{+++}	93.5	59.2	4.2	4.5
Al^{+++}	85.0	86.2	6.7	26.3

It will be seen from the table that zinc improved about $2^1/_2\%$ in the number of times correctly reported but was incorrectly reported 3% more times under the new procedure. The chromium, however, made a decided improvement, increasing from 59.2% correctly reported in 1923 to 93.5% in 1926. The per cent incorrectly reporting chromium is the same in both years. The aluminum was practically constant in the number of times correctly reported but the per cent incorrectly reporting it decreased from 26.3 in 1923 to 6.7% in 1926. This improvement is due to the effectiveness of the aurin tricarboxylate test. The manganese improved 15.2% in the number correctly reported and is incorrectly reported 2.8% fewer times. Under the new procedure the iron was reported 100% correctly, compared with 90% in 1923, but the number of times incorrectly reported increased 7.1%.

TABLE V

RESULTS OF ANALYSES OF UNKNOWNS CONTAINING ONLY IONS OF GROUP III

	Times occurred	Times tested for	% Correctly reported	% Incorrectly reported
Ni^{++}	70	141	91.5	2.6
Co^{++}	76	141	90.8	2.8
Zn^{++}	83	141	83.5	8.5
Mn^{++}	71	141	88.8	2.6
Fe^{++}	79	141	88.6	16.9
Cr^{+++}	72	141	97.2	1.4
Al^{+++}	70	141	82.8	6.2

In both years the nickel was very satisfactory, being correctly reported 97.5% of the time. The dimethylglyoxime test was used in each case. In 1923 when the cobaltinitrite test was used the determination of the cobalt ion was unsatisfactory. It was correctly reported only 76.2% of the time. Since then the nitroso-*beta*-naphthol test has been tried out and in 1926 was correctly reported 95% of the time. This is a gain

of 18.8%. There was at the same time a decrease of 4% in the number of times it was incorrectly reported.

Table V gives the results obtained by two groups in the spring quarter for the analysis of unknowns containing only the ions of Group III. It will be noted that these results are better than those obtained by the classes in the fall. These data are not entirely comparable, for the data in Tables III and IV were obtained from all unknowns containing the ions of Group III.

Summary

A modification of the procedure for the analysis of Group III of the cations is discussed in which the manganese is precipitated as the carbonate with the hydroxides of aluminum, chromium, and iron. By means of this method the detection of the zinc ion is made more certain, and the manganese ion is more satisfactorily reported.

By using the aurin tricarboxylate test for aluminum, the lead acetate test for chromium, and nitroso-*beta*-naphthol test for cobalt ions a marked improvement in the identification of these ions was made.

Faint Glow in Sky Perhaps Caused by Iron Particles. Occasionally from tropical latitudes, and less frequently from the United States, a faint glow can be seen in the sky. This is called the zodiacal light, and is seen either after sunset or before sunrise. It extends upwards parallel to the equator, long after twilight has faded away. One theory of its origin has been that a ring of cosmic dust surrounds the earth, something like the ring of Saturn, and reflects the light to us. But it may be due to a cloud of fine particles of iron completely surrounding the earth. This is the theory advanced by Dr. Elihu Thomson, director of the General Electric Company's research laboratory, in a communication to *Nature*, the British scientific magazine.

Several years ago Dr. Thomson noticed in the laboratory an effect which he thinks is similar. This was obtained with the aid of an iron arc, made by passing a current through two rods of iron in contact, and then drawing them apart slightly. The smoke, consisting partly of fine particles of iron, was passed into the field of a powerful electromagnet. When light shone on the smoke in certain ways, a large part of it was reflected, but when the magnet was turned off, the effect vanished. The effect seemed to Dr. Thomson to be due to the iron particles all arranging themselves in certain positions by the influence of the magnetic field. In this position, the light was reflected, but when the magnet was disconnected, the particles were haphazard, and the light was reflected in all directions.

Dr. Thomson suggests that iron particles may be present high above the earth. These would then be oriented by the magnetic field of the earth in such a way as to cause the effects observed in the zodiacal light. Because the light is so faint, he says, the density of the iron particles might be millions of times less than in the smoke from the iron arc.

A possible experimental check of the theory is suggested. He found that the reflected light from the laboratory experiment was polarized. No observations have yet been made of the actual zodiacal light to see if it is polarized, but if it is, and in the same way, it would support Dr. Thomson's theory.—*Science Service*

HONORS PROBLEM IN QUANTITATIVE ANALYSIS

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In order to stimulate interest and enthusiasm in a course in quantitative analysis, an experiment has been tried whereby an honors problem has been substituted for the usual final examination.

A student who has completed with average grade or better all the required exercises in the laboratory work for the semester is permitted to substitute for his final examination the quantitative estimation of some ion or element. He may choose any ion or element in reason, the only provision being that it has not been determined in the regular laboratory work. After a study of textbooks, reference works, and current literature if necessary, the student makes a list of the various ways in which the element may be determined quantitatively. From this list he chooses the method he wishes to use, and, armed with the reasons for his choice of method, with the equations for all the reactions involved, together with a knowledge of the general theory and procedure, he seeks a conference with the instructor.

At this conference the student—now as employee—lays his plan before the instructor—now employer—defends his choice of method as to its practicability and states the theory involved and procedure he expects to use. After having convinced his employer that he is capable of managing the problem, he is granted permission to start the work. At the conclusion of the problem a written report is made, including a list of references, source of procedure used, and a discussion of the probable errors.

In the writer's classes, the above experiment has been tried for the past two years and has been attended with considerable success. The opportunity to escape examination in itself is sufficient urge to keep the usual laggard up to the average of the class in work done throughout the semester, and the chance to analyze a chosen element as he wishes stirs his imagination with the thought of doing something original and different from the rest of the class. The experience gained by the student in his attempt to sell his ideas to his instructor is alone worth the effort. The student puts fully as much work and twice the enthusiasm on his honors problem that he would on study for the final examination, and the instructor is called upon to spend no more than the usual time of grading a paper. The student feels satisfaction in his work, and the instructor has the pleasure of sounding out a live student rather than scanning a dead bluebook.

The net result to the student is the pleasure in the responsibility of a piece of work, and the opportunity to show his mettle; to the instructor is the satisfaction of a semester rounded out with few, if any, laggards in laboratory work, and a class finishing a course with a bit of real enthusiasm for analytical work. This has been evidenced by the request of many

students for the chance to do a second honors problem. The student acquires experience in explaining his problem to his fellow students, who, in their turn, see many processes used which are unusual in the regular course. And, after all, when a student has made a study of textbooks, references, and current literature, has made a decision as to the method he intends to follow, and then carries out his task successfully, has he not passed a worthy examination?

Cathode Rays Make Burns Like Those of X-Rays. Injuries caused by cathode rays, streams of electrons projected from Dr. W. D. Coolidge's recently invented tube, closely resemble burns due to overdoses of x-rays and are similarly stubborn about healing. This is indicated by experiments performed by Dr. Victor C. Jacobson and Dr. Kenneth C. Waddell of the Albany Medical College, to be announced soon in the scientific journal, *Archives of Pathology.*

Rats were used as subjects of the experiments. The animals were wrapped in jackets of copper foil to protect them from being rayed all over, and only a spot about an inch in diameter on the upper abdomen was left exposed. They were left in front of the window of the apparatus for periods varying from one-tenth of a second to six seconds daily for fourteen days, while others received only single rayings of from six seconds to a minute. Current was fed into the tube at three voltages, 100,000, 200,000, and 300,000 volts, respectively.

The first sign of effect by the cathode rays was in the change of hair color, from white to yellow. Then the skin appeared to be tender, and finally developed pronounced sores, which were very slow to heal. When the rats were chloroformed and the skin subjected to microscopic examination, the details of the damage resembled closely those of x-ray burns. The experimenters state that it now appears highly likely that x-ray burns are really due to cathode rays generated by the impact of x-rays on solid or liquid objects which they encounter.—*Science Service*

Light as Length Standard Internationally Adopted. After years of painstaking scientific research an authoritative international agreement has been reached involving a single temperature scale, a fundamental standard of length, and a consensus of opinion concerning the basis of the world's electrical units.

The agreement took place at the Seventh International Conference on Weights and Measures, held recently at Paris, the United States being represented by George K. Burgess, Director of the Bureau of Standards. The conference just held was the most important in point of results secured since the first international gathering of the sort in 1875.

While the meter and kilogram have received wide general recognition, their recognition as final standards did not occur until the great nations placed their approval on them at this Fall's meeting.

The proposition of the United States to define the length of the international meter in terms of the wave-length of the red radiation from the cadmium lamp was also tentatively adopted, the final wording of the recommendation as decided on by the conference being an improvement on that submitted by the United States. Thus there is established a permanent natural standard of length, easily reproduced and capable of being used in the most precise measurements. The relationship between the international meter and the wave-length of red light from cadmium vapor is: one meter equals 1,533,164.13 wave-lengths.—*Science Service*

LECTURE DEMONSTRATIONS FOR GENERAL CHEMISTRY

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Cupric Ammonia Hydroxide—Artificial Silk

One of the methods for the manufacture of artificial silk offers an interesting and instructive experiment, well adapted to use as a lecture demonstration for general chemistry. The "Cuprammonia Process," making use of the precipitation of cellulose by sulfuric acid from its solution in cupric ammonia hydroxide, may be profitably shown in connection with the study of copper. In addition to giving an insight into an important industry, it serves to fix the attention of the student upon the peculiar class of complex ammonia compounds by showing the practical importance of one of its members.

The material may be prepared, and the experiment carried out as follows: Copper hydroxide is precipitated from a solution of copper sulfate by the addition of the proper amount of ammonium hydroxide. The solid copper hydroxide is then filtered and washed with water until practically free from ammonium sulfate when it is ready to be dissolved in ammonium hydroxide, forming the deep blue cupric ammonia hydroxide. Seven grams of the solid to every 100 cc. of 28% ammonium hydroxide, forms an effective solvent for cellulose; considerable variation from this concentration, however, will not seriously affect the success of the experiment as a demonstration. For the cellulose one may use either filter paper or ordinary cotton. Filter paper, torn into bits, will usually dissolve more readily than cotton, which has a tendency to form lumps, the inner portions of which are protected from the solvent action. Only a few minutes are required to dissolve two or three pieces of nine cm. paper in about 50 cc. of the solvent. The solution is somewhat viscous; if too much so it may be thinned by the addition of ammonium hydroxide. It has a tendency to crust over if exposed to the air but may be preserved indefinitely in a stoppered bottle.

In performing the experiment it is well to have a large beaker containing 600 to 800 cc. of dilute sulfuric acid; 6 *N* acid works very well. An ordinary pipet is then filled with the solution of the cellulose, which is next blown out into the acid through the pointed end of the pipet held just under the surface of the acid. Since the cellulose hardens as soon as it comes in contact with the acid it is well to start blowing as soon as the end touches the solution, the cellulose on emerging should form a long, deep blue thread or string, easily visible throughout a large room. After a few minutes the string will lose its blue color due to the removal of the ammonia from the complex by the acid, forming ammonium sulfate,

* Much of the work which led to the development of these demonstrations has been carried out by Myron Johnson and Clifford Carr, students in the University of Nebraska.

copper sulfate, and water. Sometimes a sack tends to form over the end of the pipet and further blowing only serves to enlarge the sack, a violent shake or two will usually jar this off and the rest of the cellulose will issue as a string.

The tensile strength of the material is not great, especially while it is wet. If it is desired to form stronger threads they should be removed from the solution of acid as soon as possible after the blue color has disappeared and washed free from the acid in several changes of water and carefully dried under tension in warm air.

Froth Flotation

It is unnecessary to go into detail in regard to the importance of the froth flotation process for the concentration of low-grade copper ores. Let it suffice to call attention to the fact that more copper has been made available for use by the discovery of this process than has been made available through discoveries by prospectors in the last quarter of a century. In spite of this importance, the method, so different from ordinary laboratory procedure, is apt to mean but little to the average student of first-year chemistry. Yet it is possible to demonstrate the essential phenomenon by an experiment requiring only common reagents and a few minutes of time, so simple and convincing that the observer can hardly fail to gain an understanding of the method even though the underlying theory be beyond his present range of comprehension.

The required materials are powdered copper, fine clean sand, cotton-seed oil, kerosene, and sulfuric acid. Because the relative quantities of the different ingredients and the method of procedure must vary somewhat with different samples of sand and copper, it is not possible to give directions which will work equally well in all cases. The commercial procedure varies in different parts of the country and with different ores. The following procedure has been found satisfactory with a number of different mixtures and it is presented with the belief that it will at least offer suggestions for a successful experiment with almost any mixture of sand with copper, copper oxide, or copper sulfide.

A small amount (0.3–0.4 gm.) of the finely powdered copper is mixed in a test tube with ten or fifteen times its weight of clean sand. The tube is then half filled with water and a few drops of sulfuric acid are added and mixed. Cotton-seed oil is next poured into the tube forming a layer from 0.5 to 1.0 cm. thick, depending on the amount of copper present, a drop or two of kerosene is then added and the whole shaken vigorously. On being allowed to settle the sand will fall to the bottom and the copper-coated oil bubbles will rise to the top, leaving relatively clear water in between.

If it is desired to devote more time to the demonstration one may

first follow the above procedure using only sand, no copper; the froth will form but it will not be coated. A second trial using only copper will show that it is taken up by the froth. The experiment as described above should next be tried in order to show that the method will bring about a separation of a small amount of copper from a large amount of sand.

Precautions to be observed in order to insure a good demonstration are: do not use too much copper or copper of too coarse a grain as the bubbles cannot hold it up; do not shake it too long or vigorously or the oil will emulsify and not settle out readily. More oil in proportion to the amount of the mixture is necessary for a demonstration of this type than is used in commercial practice because it is desired to bring about a separation that will be obviously complete; in other words, we desire all the copper to float while the liquid is quiet. In practice a rapid stream of water and perhaps of gas bubbles helps to secure the separation.

California Steam Wells Examined by Scientists. Steam wells, where the earth is tapped for natural heat as it is elsewhere for natural gas or oil, promise to deliver power in paying quantities and at the same time to yield data of value in the study of the ancient riddle of geysers, hot springs, and fumaroles.

The first development of this kind in America, at "The Geysers" in California, has been given a thorough scientific examination by Dr. E. T. Allen and Dr. Arthur L. Day of the Carnegie Institution of Washington, and their report has just been made public.

The steam well region is in a little valley in the Coast Range, near San Francisco. There is abundant evidence that the region saw much volcanic activity in the past, and the steam rising through the earth, causing fumaroles and hot springs, is probably the product of deeply buried lava that has not yet cooled. The name "The Geysers," however, the Washington scientists state, is a misnomer, for there are no active geysers in the valley and no signs that there ever were any. Even the natural steam and hot water escapes are less marked than they are in many other similar regions.

Nevertheless, there seems to be abundant steam at high temperatures and pressures when the borings are sunk. Eight wells have been put down so far, to depths of between 200 and 650 feet. These develop steam pressures between 60 and 275 pounds per square inch. Quantitative measurements of the output of four of the wells indicate a power equivalent to 4500 kilowatts, or over 1000 kilowatts per well.

In spite of the borings, no diminution of steam flow at the natural fumaroles in the valley has been noted. Neither do the wells seem to diminish each other's activity, although two of them are within 50 feet of each other. In fact, all the wells have shown an increase in both the pressure and temperature of their steam for a certain period after they were first opened.

A similar enterprise on a larger scale has been conducted at Larderello, Italy, where the commercial production of power has already been realized. The California development has one advantage over the Italian wells, in that the Larderello steam contains corrosive acids, which fact necessitates more or less elaborate purifying processes before it can be used, whereas the California wells yield a steam whose acidity is so low that it can be used in its natural state.—*Science Service*

AN APPARATUS FOR INDICATING THE CONDUCTIVITY OF SOLUTIONS AND OF FUSED SALTS

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The laboratory exercises in many elementary chemistry courses include an experiment that qualitatively indicates the electrical conductivity of various solids, liquids, and solutions. A common fault, with most of the various forms of apparatus that have been designed for this purpose, is the ease and frequency with which the electrodes are brought in contact with each other thus causing a short circuit. The apparatus here illustrated avoids this trouble. It is easily and cheaply "home made." We have used this apparatus with several hundred students annually for the past five years. We find it satisfactory.

The accompanying drawings, Figs. 1 and 2, show the general appearance and the wiring diagram, respectively. Referring to Fig. 1, the boards on which the apparatus is built are three-fourths by six by eighteen inches. The lamps are thirty-watt, one hundred twenty-volt lamps. The insulated copper wire, held in place by the porcelain insulators, is one-sixteenth inch in diameter. All of the electrodes are made of copper rods one-eighth inch in diameter. Each electrode is threaded at the upper end to hold two nuts, one above and one below the board. Between the nuts, washers form suitable contacts in the wiring system and with the board. The pilot lamp at the reader's left is joined by flexible lamp cord to the outlet of the public service lighting circuit, which supplies the necessary current.

While in use the apparatus is supported either by two nails driven in the wall through holes bored in the upright board or else by two ring stands. The lower ends of the electrodes should be twelve or more inches above the desk. The substance to be tested is placed in either a beaker or a wide-mouthed bottle and is raised in a position such that one pair of electrodes will be submerged. The extent of conductivity is indicated by the brightness of the glow of the test lamp at the reader's right. Between successive tests the electrodes are rinsed with water and wiped with a towel. We have used one pair of electrodes for solids, one for aqueous solutions, and the third pair for non-aqueous solutions. After five years of use the original apparatus is still serviceable. The original electrodes are still in place and are only slightly corroded.

Since the foregoing was written we have learned that the apparatus just described serves very well in the following experiment.

The apparatus is set up as if for use in indicating the conductivity of solutions. When the electrodes are dipped into fused potassium nitrate, the test lamp glows brilliantly indicating that the fused salt is a good conductor. As the salt cools and solidifies the light fades and becomes

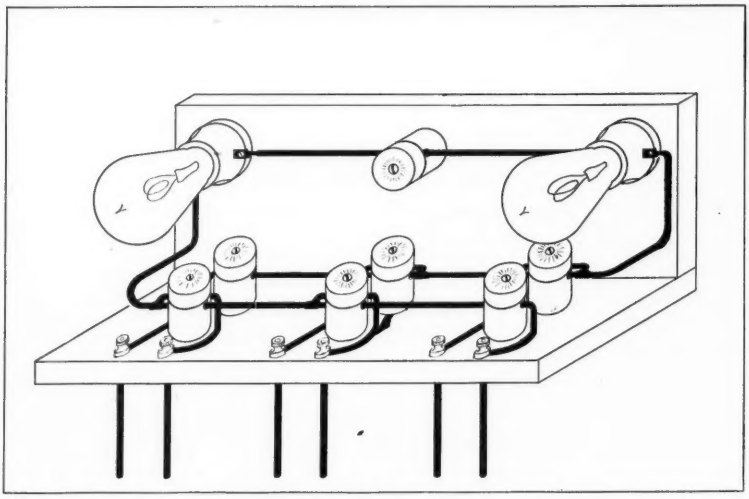

FIG. 1.—GENERAL APPEARANCE OF THE CONDUCTIVITY APPARATUS

invisible, indicating that the solid salt is a poor conductor. Potassium nitrate (melting point 337°) is easily fused in a pyrex beaker by the heat from a bunsen burner. Other salts may be used.

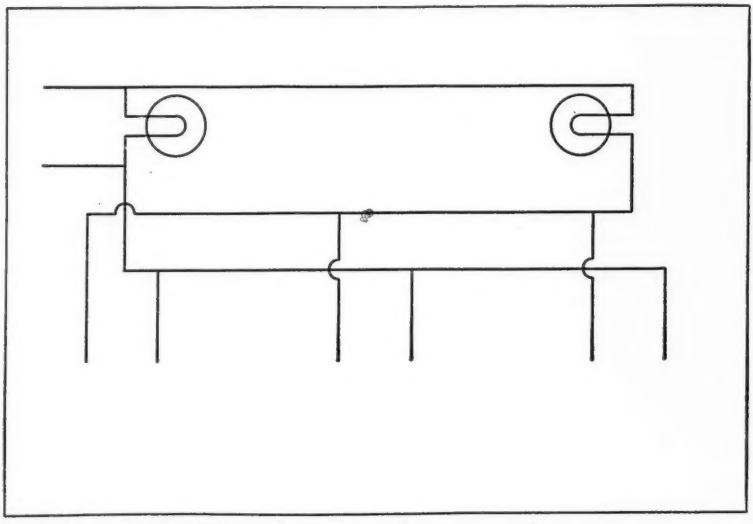

FIG. 2.—WIRING DIAGRAM FOR CONDUCTIVITY APPARATUS

Correspondence

STUFFING THE GOOSE

This is the way geese are prepared for market. When they are of full size the peasant woman feeds them with as much as they will eat and then stuffs them singly with all the food they will hold. This makes them fat and ready for market. My wife saw this done in the old country when she was a little girl and has often described the process. While I was actively engaged in teaching chemistry I never thought of trying this process on my pupils although I taught chemistry for fifty years, which shows how dumb I was, but now I see it going on everywhere: which shows how modern we all are. My plan in teaching chemistry was founded on the supposition that it would take my students as long to learn chemistry as it had taken me. I got along with the boys fairly well in working out this plan but found I could do still better when all my experiments worked and when, sometimes at great trouble, I had succeeded in getting together and showing them interesting things they had not seen—cotton bolls when we talked about cellulose, sugar cane, and maple and beet sugar, and a great variety of other things new to many of them. It was sometimes an awful job to lug these things around but I thought it paid, and after a while I discovered that my course was much like the one at Harvard, though they had been planned separately, except that their course was somewhat better than mine. I used my own textbook which was planned to contain *as little as possible*. Everything possible was left to the second year. Then I took up the gas laws and the other elementary physical questions and went further in organic chemistry. When I had done my best with the chemists I gave them a subject and *no help*. They were learning to fly and I pushed them out of the nest. When they came to me I told them where to find the information they wanted. At the end of three months they very seldom had found any very new things in chemistry but, if they had been diligent, they had learned to fly. I cannot think my students were more than ordinarily stupid, so I have concluded that much that we see in undergraduate theses, and sometimes I fear from Ph.D. men, must really come straight from the professor's brain. When I look at the size of the textbooks used nowadays I see quite plainly that the stuffing process is in full blast, and since the size of these books is growing as chemistry grows, must be constantly growing more strenuous.

As much as ten years ago I found I had a few hours to spare each day and undertook an experiment: I went into the French and Italian classes

of a very good teacher in our college here. I soon found the lessons were entirely too long for me. Of course I am slow, but so were some of the boys. On inquiry I discovered that my teacher was not setting the lessons; if he had been they would have been shorter: they were set by the head of the department.

College boys come to college from very different environments. Some of them are very green—as I was and as Dr. Harvey W. Wiley tells us he was in the long ago. How can these boys be expected to know the things at the start that others have learned long ago from a better environment? Some of the finest men I have graduated were from these humble beginnings. We are sorting the men and refusing many nowadays. If we are not very careful we shall be making some serious mistakes in the very beginning. Perhaps there may be something in these psychological investigations, but I am very sure the quickest thinkers are not always the best thinkers. Teaching has always had faddists in plenty. I never could see much in their fads. When I was a boy, Brooks, with his mental arithmetic, was all the rage. He was a good seller of an idea and his idea was widely adopted. Physical exercise then had a chance. I used to get up at 5 A.M., milk four cows, and help clean the stables. Then I went to school and the woman teacher of elocution threw open the windows and put us through a gymnastic drill—but I had plenty of exercise and so had many of the others; only the teacher was suffering.

And so it goes. I long ago discovered that a little common sense is necessary in teaching as in anything else. Indeed, I have slowly become convinced that common sense is the most precious thing we have, that those who do not possess it can never make good teachers and should never be allowed to teach at all.

EDWARD HART

LAFAYETTE COLLEGE,
EASTON, PA.

Shipworms Digest Wood, Scientists Find. Shipworms, the pest of many a waterfront because of their depredations on both wharves and ship bottoms, can actually digest wood.

Professors Lyman C. Boynton and Robert C. Miller, of the University of Washington at Seattle, reported to the American Society of Zoölogists recently that an extract from the digestive organs of teredos or shipworms would convert small quantities of sawdust and pure cellulose in the shape of filter paper into sugar. Since the reaction took place in 30 per cent alcohol, a medium not particularly kindly to microörganisms, the scientists assumed that the conversion was due to an enzyme rather than to bacterial action.

Dr. Ellinor H. Behre, of Louisiana State University, addressed the same section on the reactions of certain species of fishes that record their perceptions to light rays of different wave-lengths by changing color. Fishes that are completely blind do not register a change, the zoölogist found. The fish become darker in daylight and lighter in darkness, she declared.—*Science Service*

Chemical Digest

ABSTRACTS

The High School as a Community Center. COMMITTEE REPORT. *H.-S. Quart.*, **16,** 239–48 (July–Oct., 1927).—A plan of social democratization would be to place the facilities, equipment, and resources of the schools at the service of all citizens of the body politic. In connection with such a plan, there is discussed at considerable length evening, part-time day, adult day, and vacation schools. No attempt is made here to justify the utilization of the school buildings as social centers of community activities. This plan is thoroughly recognized in educational policy. In this connection are discussed athletic games and exercises, patrons' institutes, the community laboratory and bureau of local research, voting centers, parent-teacher meetings, and quasi-private clubs. J. H. G.

A Plea for Academic High Schools. W. W. COMFORT. *Gen. Mag. and Hist. Chron.*, **30,** 20–4 (Oct., 1927).—Forced by increasing population, school boards have had to resort to wholesale methods of class-room instruction. There is less intimate contact between teacher and pupil. We learn better from teachers than we learn from books. There is a commendable effort being made to secure better trained teachers but what is preventable and what many regret is the present tendency of teachers to seek promotion by taking courses in pedagogy leading to the Master's degree. Reference is made to the article in *American Mercury* for May, 1927, ridiculing our national passion for pedagogy. Seeing the way promotion lies, too many teachers are spending their vacations studying "methods" and "technic" rather than profitably studying the subjects which they are engaged to teach. Pupils often bear testimony to their appreciation of the teacher who is master of his subject and who is able to arouse the interest of the class by contagious enthusiasm. Students are right and school authorities are wrong in their sense of teachers' values. Two qualifications for teachers of the past have been love of youth and grasp of their subject. For neither one of these need one go to Teachers' College. The curriculum is filled with too many unrelated subjects. If the student finds Latin too hard, he takes Spanish; for physics he takes general science. The disciplinary value of education is seriously threatened. Comfort refers to the establishment of an academic high school in which students can be adequately prepared for college and subsequent professional careers. The advantage of the academic high school consists in harboring only those subjects calculated to develop the intellectual powers. In such a school the course could be rigidly prescribed to consist primarily of English, Latin, and mathematics. Avoid superficiality which is the curse of American education in general. The experience of Comfort has been that there is no substitute for the classics and mathematics as a foundation for the study of the exacting arts and sciences of higher education. J. H. G.

Socialistic Trend in Education. G. D. DARTE. *Gen. Mag. and Hist. Chron.*, **30,** 51–66 (Oct., 1927).—We are educating a nation to the theories of socialism. Socialism is communism, and communism is old-time illuminism which set forth as objectives the abolition of government, patriotism, the property rights, inheritance, religion, and family relations. J. H. G.

Svante August Arrhenius, 1859–1927. W. A. NOYES, JR. *Chem. Bull.*, **14,** 272–3 (1927).—With the passing of Arrhenius, science has lost a genius who did much to elucidate its hidden secrets. He began his brilliant scientific career early in life. Many of his ideas of electrolytic dissociation were included in his doctor's dissertation, in fact, his doctor's dissertation was so "radical" that he had to modify it before it would be accepted by his professor, who even then accepted it with reluctance. His own Swedish contemporaries gave him recognition only after Van't Hoff and Ostwald had recognized him as one of the outstanding scientists of his day.

After Arrhenius received his degree he went to Ostwald's laboratory at Riga. He followed this with work under Kohlrausch at Wurzburg and Boltzmann at Gratz and a most significant period under van't Hoff at Amsterdam, returning finally to Ostwald's laboratory and publishing his classical paper on electrolytic dissociation in 1887 at the age of twenty-eight. The acclaim given him in foreign countries found an echo in Sweden and he returned although offered exceptional positions in Germany.

After a period at the Hochschule at Stockholm he became the director of the Nobel Institute for Physical Chemistry, a position which he held until his death. His honors were many. In 1903 he was made a Nobel laureate; in 1905 an honorary member of the American Chemical Society; and in 1911 received the Willard Gibbs Medal. He has also given the Silliman lectures at Yale University. His death closes an almost unparalleled career in the science of chemistry. E. L. M.

True-False Tests—Success or Failure. WINONA M. PERRY. *Neb. Ed. J.*, **7**, 423–5 (1927).—A protest has been registered against true-false tests as tests "of questionable value," while recently another statement declares them to be one of the most effective aids in the educative process. The writer considers which position on this matter is the more logical one and as a result chooses the latter position. Her choice is based on (1) the social worth of the content, (2) the value (formation of habits, measure of skill, incentive for others) derived from practice with achievement tests, of which true-false tests are merely one form, (3) the consideration of the product of learning as being more important than the process of learning, (4) the correctness of grading, (5) the time saved for instruction, (6) the measurement of power and ability, (7) the eradication of guessing, and (8) the intrinsic worth of such tests. E. L. M.

Teaching the Art of Study. WM. J. O'SHEA. *School*, **39**, 153–5 (Oct. 27, 1927).—District superintendents and their teachers under the guidance of Supt. Wm. J. O'Shea of New York City Schools have taken up the problem of the study habits of their pupils. A composite of their work is now issued. Salient points in this issued abstract are: (1) Causes of deficiency in study. (2) Consideration of what study really is. (3) Ways and means of improving study. (4) Special help in training in the art of study for specific subjects. (5) End-products of successful study recognized and evaluated. E. L. M.

Purer, Whiter Salt. R. K. WARREN. *Inco*, **7**, 6–9 (1927).—Salt reclamation from its brine involves evaporation, often under reduced pressure. Crystallizing from a relatively pure solution, the product's purity is, in a large measure, dependent upon the care exercised in its handling. Pure white salt then becomes a matter of preventing discoloration and contamination after it has been thrown out of the brine. Monel metal has been found exceedingly well adapted to use for transfer belts and screw conveyors, both because of its own freedom from corrosion and its resistance to the abrasion by salt crystals. B. C. H.

Comparison of Lecture Demonstration and Individual Laboratory Methods of Performing Chemistry Experiments. DAVID B. PUGH. *H.-S. Teacher*, **3**, 384–6 (1927).—This is the report of an experimental study using two classes of high-school boys studying chemistry. There were 42 boys in the lecture-demonstration group with a mean I. Q. of 119, and 28 in the individual-laboratory section with a mean I. Q. of 123.9.

Results were measured by an unstandardized battery of eighteen tests. Outcomes sought were: retention, mastery, resourcefulness, and application.

A check-up on mastery showed the lecture-demonstration group to be something like 10% more efficient than the other groups.

Retention tests given at time intervals of one, two, and twenty weeks, showed the lecture-demonstration group medians 21.5, 18.3, and 5.2 points, respectively, above the other group.

Two tests of the eighteen were designed to determine resourcefulness and application. In these the group depending upon demonstrations had a median 25 and 6.8 points higher than the other group.

The experimental teaching practice was followed but one semester. Both groups were thrown together the second semester and taught by the individual-laboratory method. Even so, the total value of grades in chemistry at the end of the second semester was 85 to 56 in favor of the students who had the lecture-demonstration method treatment the first semester. B. C. H.

The Relation of Chemistry to National Defense. C. RUTENBER. *Chem. Warfare*, **13**, 188–95 (Oct., 1927).—The part played by chemistry in controlling disease, improving living conditions, and in other aids to public health is outlined. The importance of preparing and canning complete foodstuffs is explained. The development of munitions of war, gas, gas masks, and high explosives is given in some detail. The uses of these various products in peace-time industry is described.

This article should be of interest to those students competing in the A. C. S. Prize Essay Contest. E. R. W.

Art of Hardening Copper Not a Mystery. ANON. *Compressed Air Mag.*, **32**, 2215–9 (Oct., 1927).—The ancients hardened their copper and bronze tools by hammer-

ing the cold metal, either nearly pure copper or an alloy, with some metal such as tin, iron, zinc, etc. Not only do modern metallurgists understand how the ancients hardened their copper implements, but they are able to make such products even harder than could our predecessors. E. R. W.

The Seven Lamps of Chemical Enterprise. C. T. J. CRONSHAW. *Chem. & Ind.*, **46,** 957–61 (Oct. 21, 1927).—This rather unusual article explains in an interesting manner how the path of chemical enterprise, which is ".... both long and sinuous, and beset with pitfalls...." is lighted by seven lamps. The guiding lamps which he describes in detail are: Research, precision, service, unity, judgment, leadership, vision. Vision, "....to make harvests in the future so abundant that succeeding generations may straighten shoulders no longer burdened as are ours." E. R. W.

How One Food Manufacturer Coöperates with Teachers. M. F. BROWN. *Am. Food. J.*, **22,** 238 (July, 1927).—A discussion of the booklet "Hob O' the Mill" put out by the Quaker Oats Co. This booklet was published especially for use in schools and contains material which may be used for stories, dramatization, or projects. It is authentic and well adapted to its purpose. J. W. H.

A Declaration of Independence for Public Education. H. SUZZALLO. *Sch. and Soc.*, **26,** 89–96 (July 23, 1927).—No institutional development of the past century can be compared in power and influence with the American System of public education. This system, created by the common people who cast out the exclusive academy and placed primary and secondary schools within reach of all—meeting additional needs through the junior high schools and colleges, gives to every child the right to determine his abilities and the opportunity to develop them to the highest degree. Unfortunately, the constitutions formerly formulated provided no protection against political interference and the enemies of education found every reason for believing that they should decide what should be taught in the schools and colleges. Let the ultimate purposes of schools be decided by the laity, but let the manner in which to accomplish the particular results demanded for the money available, be left to the scientifically trained scholar and educator.

The minds of the school children should be opened by the search for truth and not closed by propaganda, as has been the case in Russia, and was partially the case in Germany before the war. Many factors are exerting an influence which seems destined to break up the balanced program of the schools—a program designed for the development of wholesome human character and personality. It too frequently happens that in the higher schools, the members of the governing boards, having been appointed by the governor rather than elected by the people, are politically and not educationally minded. Despite the fact that history has taught that church and state are better apart, theological factions are beginning to intervene. K. S. H.

Salaries of College Instructors on Pre-War Basis. J. W. CRABTREE. *Sch. and Soc.*, **26,** 207–8 (Aug. 13, 1927).—Under the direction of the Representative Assembly of the N. E. A., state and national associations are to make a study of college professor's and instructor's salaries, placing the facts before college authorities and the public, in an endeavor to relieve a situation which has long existed. It is well known that college graduates go out to teach in high schools, receiving salaries considerably above that paid to instructors in colleges. Were the public to demand that professors and instructors receive such salaries as would attract good teachers to the colleges, the reasons why so many promising high-school graduates drop out of college the first and second years might be solved. K. S. H.

Who Should Go to College? F. L. MCVEY. *Sch. and Soc.*, **26,** 410–4 (Oct. 1, 1927).—The entire educational system of the U. S. appears to be involved in the question, "Who should go to college?"—for certainly the training of the youth of the country and the national concept of education are important. The writer quotes statistics in explaining the problems which exist in American education today. Examinations, mentality tests, etc., have been resorted to in an effort to eliminate those who are not considered college material, but these affect only a relatively small percentage. Whether or not the junior college will solve the difficulties in the universities, remains to be seen.

In answering his question, the writer quotes Mr. Herbert Hoover as saying, "Anyone who can do the work..." and also Armand Miller who says, "An individual who has an honest-to-goodness, legitimate motive...; those who rank in the upper two-thirds of the graduating class... and, those who possess poise and self-restraint."

After discussing the educational objective, Mr. McVey states that the reorganization of secondary education, defining the college and limiting the university to the real function would relieve the universities and colleges from many who now crowd its doors. K. S. H.

Local Activities and Opportunities

Nebraska. The following are the Scholars at the University of Nebraska for the year 1927–28: John Taynton Murchison, A.B., June, 1927, U. of N.; John C. Zimmer, A.B., 1927, U. of N.; Clare Prather, A.B., 1921, Southwestern College; Warren H. Steinbach, B.S., 1926, Hastings College, Hastings, Nebr.; William Wells, B.S., 1927, Cotner College, Bethany, Nebr.; Harry Elvin Hart, B.S., 1925, York College, York, Nebr.; Robert Eugene Etzelmiller, A.B., 1923, Cotner College; Clyde Wilson Eddy, B.S., 1927, South Dakota State College; John Stanley Chambers, B.S., in Chem. Eng., 1924, Univ. of Denver; Ernest Grinnell Almy, B.S., 1926, Univ. of Nebr.; Robert R. Ralston, B.S., 1926, Tarkio College, Tarkio, Mo.; Frank J. Prochaska, A.B., 1926, Doane College, Crete, Nebr.; Albert Graham Moseley, Jr., A.B., 1926, Howard College, Ala.; Edwin Lorenzo Mattison, A.B., 1926, Southwestern College; Edwin A. Fluevog, A.B., 1926, Univ. of North Dakota; Sebastian Anthony Durban, M.A., 1923, U. of Texas; Edward Franklin Degering, A.B., 1924, Union College, College View, Nebr.

Science received recognition in the State Teachers' District meetings, Nov. 2–5, as follows:

"What Pupils Should Get from Their Study of Science," Professor F. G. Collins, University of Nebraska.

"The High-School Museum," Professor Robert Coatney, Grand Island College.

"The Need of More Biological General Science," Leona Woods, North H. S., Omaha.

"Bird Study with a Travelling College Class," Mollie Vlassik, Wayne.

"Making the Biology Course Function," Prof. H. E. Alder, Neb. Wesleyan Univ.

"The High School Library," B. Clifford Hendricks, Univ. of Neb.

"Contract Method of Teaching Science," R. Dalstrom, Central City H. S.

"Everyday Science," Mary Stephen, Lodgepole H. S.

"The Teaching of High-School Science," T. F. Zeigler, Scottsbluff High School.

Doctor Herbert A. Senter, for the past thirty years teacher of chemistry and now dean of Omaha Central High School, was elected a vice-president of the N. E. A. at its last meeting.

Professor Royce Le Roy, of Doane College, is the author of the leading paper on "Teaching the Periodic Classification of Elements" in the November issue of *School Science and Mathematics*. Doctor B. Clifford Hendricks presented an article "The Chemistry of Power" in the October issue of the same magazine.

The University of Chicago. Dr. Warren C. Johnson has been appointed instructor in general and inorganic chemistry to succeed Assistant Professor Terry McCoy, who resigned last March. Dr. Johnson comes from Clarke and Brown Universities, where he acted as research assistant to Professor Kraus.

Dr. Leslie Hellerman, who has been research instructor coöperating with Professor Stieglitz, has received an appointment in the department of physiological chemistry of the Johns Hopkins University Medical School as associate (equivalent to the usual assistant professorship). Dr. Hellerman will be very greatly missed in the department.

Messrs. J. B. Culbertson, W. N. Herr, L. S. Kassel, and J. S. Hicks took their Ph.D. degrees at the autumn convocation. The first two have academic appointments, Mr. Hicks an industrial research appointment, and Mr. L. S. Kassel has received a National Research Fellowship

and is working at the California Institute of Technology in Pasadena.

Ohio. "Teaching as a Fine Art" will be the keynote of the Eighth Annual Ohio State Educational Conference which the College of Education, Ohio State University, will conduct at Columbus on April 12th, 13th, and 14th. Last year, with an attendance record of 4500, the Seventh Annual Conference quite shattered all previous registration figures. The Executive Committee for the 1928 Conference anticipates that the "new record a year" tradition will be continued this year.

As in the past, the sectional meetings, held throughout Friday, the second day of the Conference, will feature the three-day session. This provision for group meetings by school people of the State whose interests and problems are similar has met with such evident approval that meetings must now be scheduled, in many instances, in both the morning and afternoon for certain of the sections. In order to avoid the overlapping which necessarily occurs when the sectional program is extended, some of the group meetings have been scheduled this year for Thursday afternoon. This will be the first Conference at which any meetings have been held in advance of the opening general session held on the evening of the first day.

The following sectional meetings have been arranged for the 1928 Conference. Thursday afternoon, April 12th: City Superintendents, County Superintendents, School Librarians, and Parent-Teacher Associations; Friday, April 13th: Art, Biological Science, City Superintendents, Clinical Psychology, Commercial Education, Deans of Women, Educational and Intelligence Tests, Elementary Principals, Elementary Teachers, English, Geography, High-School Principals, History, Home Economics, Industrial and Vocational Education, Journalism, Junior High-School Principals, Kindergarten and Primary Teachers, Latin, Mathematics, Modern Language, Music, Non-Biological Science, Physical Education, Religious Education, School Business Officials, Special Education, Teacher Training, Village and Consolidated School Superintendents.

Lexington Section, A. C. S. held its 123rd regular meeting at the University of Kentucky, Wednesday, December 14th.

A motion picture film entitled "How Bacteriological Products Are Made" was shown by Mr. Truesdale of Parke, Davis & Company.

Following this, Dr. Albert P. Mathews, professor of biochemistry of the College of Medicine, University of Cincinnati, spoke on "Recent Progress in the Field of Vitamins."

Cincinnati Section, A. C. S. The 294th regular meeting of the Cincinnati Section of the American Chemical Society was held in the Chemical Auditorium of the University of Cincinnati, on Wednesday evening, December 14th, at 8 o'clock.

The speaker of the evening, Dr. Edward Mack, professor of physical chemistry in Ohio State University presented a paper on "The Size and Shape of Organic Molecules."

The Chemistry Library of the University of Cincinnati is now open from 6 to 9 P.M., Monday to Friday inclusive, for the convenience of those who are occupied during the day. A trained librarian is in charge and she will gladly render assistance in the location of material. Access to the stacks and to the current periodicals is granted to all, greatly facilitating literature searches. This venture is an experiment and its continuation will depend on the visible demand as evidenced by the patronage of the chemists of this vicinity. It is said that this library is one of the best college chemistry collections in the state, if not in the country.

University of Arkansas. A fund for the encouragement and stimulation of research in the College of Arts and Sciences has been authorized by the University.

Of this fund a portion has been devoted to the assistance of research in organic chemistry. At present this is being used by Dr. Edgar Wertheim to aid the progress of experiments with aromatic sulfur compounds.

Cleveland Section, A. C. S. The December meeting of the Cleveland Section of the American Chemical Society was held at 8.00 P.M. in the lecture room of the Physics Bldg., Case School of Applied Science. Dr. W. R. Veazey, professor of chemical engineering and head of the department of chemical engineering at Case School of Applied Science, spoke on "The Chemical Aspects of Cleveland's Growth."

As this was the Annual Meeting of the Section the following were chosen as the officers of the Section for 1928: *Chairman*, N. K. Chaney of the National Carbon Co.; *Vice-Chairman*, M. J. Rentschler of the J. H. R. Products Co.; *Secy.-Treas.*, W. L. Reinhardt of the Willard Storage Battery Co.; *Councillors*, O. F. Tower of Western Reserve Univ., M. J. Rentschler and N. K. Chaney.

Georgetown University. The seventh annual conference of the eastern section of the Association of Jesuit Scientists was held the past summer during August 12th–14th at Holy Cross College, Worcester, Mass. Father Geo. L. Coyle, the head of the chemistry department of Georgetown University delivered an interesting paper on Chemotherapy. Mr. Lawrence C. Gorman, S. J., a member of the chemistry staff, read a paper entitled "Teaching Freshman Chemistry."

Father Coyle, as representative of Georgetown University, attended the formal opening of the William H. Nichols Building for Chemistry at New York University, New York City.

The first public meeting of the Chemistry Academy of Georgetown University for the current scholastic year was held Thursday evening, December 1st. The meeting was attended by a large gathering who were tendered a real treat in the entertaining and enlightening lecture delivered by Dr. Harrison E. Howe, editor of *Industrial and Engineering Chemistry*.

A new quantitative laboratory accommodating 117 students was built during the summer in the place formerly occupied by the chemistry office. The new office of the department of chemistry now occupies the former quarters of the staff of the *Hoya*, the weekly paper. The room was completely renovated during the summer and affords sufficient space for a small private office for Father Coyle, and a large general office for the other members of the staff. It was necessary, during the summer, to build 132 new lockers to accommodate the increasing number of freshmen taking chemistry.

Mr. P. Francis Wilson, Mr. Arthur A. Espenscheid, and Mr. John F. Sheehan of the department received their Master of Science degrees last June. Mr. Espenscheid is to teach quantitative chemistry to the sophomore B.S. students starting the second term. Mr. Wilson has been assigned to teach inorganic chemistry to the sophomore A.B. students. Mr. George Robertis, a former teacher at Revere High School, Revere, Mass., and later at Mechanics Arts High School, Boston, Mass., is a new member of the staff.

Pennsylvania State College. "Magnetism and Magnetic Materials" was the topic presented at the December meeting of the Central Pennsylvania Section of the A. C. S. The speaker was Dr. T. D. Yensen of the Research Laboratory of the Westinghouse Electric and Manufacturing Co. Dr. Yensen has done much valuable work in the development of magnetic materials.

Dr. Wheeler P. Davey, professor of physical chemistry, addressed the Chicago Section of the A. C. S. at the November meeting. His topic was "What the Chemist Should Learn from X-Ray Examination of Crystals."

Dean Gerald L. Wendt presented a report on "A State Science Association" at the holiday meeting of The Pennsylvania State Educational Association at Lancaster, Pa.

Recent Books

Recent Advances in Organic Chemistry. ALFRED W. STEWART, D.Sc., Professor of Chemistry in the Queen's University of Belfast. 5th ed. Longmans, Green & Co., London and New York, 1927. 2 vols., xiv + 387 and xiv + 382 pp. 14 × 21.5 cm. $7.50 each.

This book, which has given aid and inspiration to many for nearly two decades, has been rewritten and enlarged and now appears in two volumes. The object is to give vivid pictures of recent developments in selected fields rather than to cover the whole of organic chemistry. Each chapter is complete in itself.

Volume 1 contains chapters on: Main currents in organic chemistry, modern reagents, addition reactions, aliphatic diazenes, ketenes, polyketides, monocyclic, dicyclic, and olefinic terpenes, pyridine alkaloids, quinoline alkaloids, purines, polypeptides, trivalent carbon, unsaturation, and orientation in the benzene system. Volume 2 is more than half new and contains chapters on: Organic chemistry in the 20th century, some carbohydrate constitutions, sesquiterpenes, rubber, recent work on alkaloids, anthocyanins, chlorophyll, depsides, theories of the natural syntheses of vital products, new organo-alkali compounds, abnormal valency, structural formulas and their failings, some applications of electronics to organic chemistry, and some unsolved problems.

The topics are well selected and discriminatingly treated. This book will prove valuable to ambitious students who wish to go beyond the textbooks and will greatly aid teachers in the impossible task of keeping up with organic chemistry. It is well worth while.

E. EMMET REID

A System of Qualitative Analysis for the Rare Elements. ARTHUR A. NOYES, Professor of Chemistry, California Institute of Technology, and WILLIAM C. BRAY, Professor of Chemistry, University of California. The Macmillan Co., New York, 1927. xii + 536 pp. 14 × 21.5 cm. $5.00.

The aim of this book, as stated in the preface, is three-fold: first, to supply the chemical analyst with a system of procedure which will enable him to detect the various elements in all their combinations by as simple a process as possible; second, to record the numerous experimental investigations that have been carried out in developing this System of Analysis; and, third, to provide for students a course in advanced inorganic chemistry that will afford them an acquaintance with the chemical properties of the rarer elements, many of which have now become highly important. The first two of these aims are evident in that there are really two volumes bound in one; the first extending to page 267, giving the system of analysis with procedures and notes; the second, the balance of the text, giving the confirmatory experiments on which the system is based. The third aim receives attention through suggestions under the heading, "The Course of Study," in the first few pages of the book. Fortunate the school that can find time in its schedule for such a course and students free to elect it from the multitude of courses now appearing in the average chemical curriculum!

This is a book that has been eagerly awaited by the analytical chemist and that now supplies him with an immense fund of practical information. The attempt to fit all the metals into a single systematic procedure for qualitative testing represents a culmination of the older point of view in analytical chemistry

in which the analyst tried to determine on a single sample all the constituents in which he was interested. Today it is recognized that methods of separation must be varied according to the constituents present, that there is no single best method that can always be used. Therefore, this volume is valuable, less for the practical system of analysis developed with its apparent usefulness, than for the vast store of data in that part recognized by the authors themselves as being their main contribution, namely, the confirmatory experiments. Copious references in this part of the book add distinctly to its value.

With a book so very well done it seems petty to search for minor imperfections. It may be noted incidentally, however, that of the metals listed in the table on page 503 only Terbium, Radium, and Radon are missing in the outlines. The two metals Samarium and Yttrium are still represented by the older symbols Sm and Y in the body of the text instead of the more modern Sa and Yt. Glancing through the index, which seems very complete, the rare earth metals Dysprosium, Holmium, Lutecium, and Thulium are missing, though they appear in the tabular outline on page 210.

It is not a volume for easy reading, but with so remarkable a quantity of experimental work summarized in its pages, it belongs on the shelves of every chemist interested in the inorganic and analytical field, and should prove exceedingly valuable to teachers of advanced inorganic chemistry. R. K. MCALPINE

Muscular Movement in Man: The Factors Governing Speed and Recovery from Fatigue. A. V. HILL, Foulerton Research Professor of the Royal Society of London: The George Fisher Baker Non-Resident Lectureship in Chemistry at Cornell, 1926–1927. Volume 3. McGraw-Hill Book Company, Inc., New York, 1927. xii + 93 pp. 15 × 22.5 cm. 32 illustrations. $2.50.

A publication by Dr. Hill is always welcome. This one, written in the charming style so usual with the author, concerns his recent experiments on muscular movement, especially during violent exercise. The first ten chapters deal with observations made upon athletes, the remainder with experiments upon isolated muscles, these being the necessary precursors to the human experiments. Deductions made from the human experiments were based largely upon the study of the differences existing in the oxygen consumption before, during, and after exercise. From these data the author has drawn many interesting conclusions as to the maximum speed, fatigue, and recovery. The "buffers" of the blood and tissues are treated in a most instructive manner. Practical application of the findings to athletics is made in chapter ten. The book carries with it a plea for chemists to interest themselves in this type of chemistry, biochemistry, and thermodynamics; to interest themselves in this difficult chemical and physical problem elicited by the power which a muscle possesses of transferring chemical energy into mechanical work, while maintaining a constant temperature and a fairly high efficiency. It is an exceedingly fascinating book by an authority, and for the most part comprehensible even to mediocre chemists. H. B. HAAG

Chemistry. J. ELLIS STANNARD, A.B., Pd.B., Boys' High School, Brooklyn, New York. Oxford Book Company, New York, 1927. iv + 251 pp. with 24 figures. 13.5 × 19 cm. Paper cover, 68 cents, postage paid.

"The aim of this book is to present a comprehensive, accurate, and pedagogically sound review of elementary chemistry as taught in the best American High Schools." The book is designed to meet the 1926 Syllabus of the Board of Regents for the State of New York, and the College Entrance Examination Board.

It is probably true that a review of this character does not lend itself readily to original treatment. It is no fault,

therefore, that it follows conventional lines, nor does this in any way detract from its value. This review consists of brief statements in place of the topics of the syllabi and the pupil, therefore, finds important items readily. The diagrams are chiefly of laboratory apparatus.

Questions of about the same type as those in most elementary texts are included in each chapter; the answers to most of these can be found in the body of the review itself. Answers to the numerical problems are found in the appendix.

The appendix also contains "important definitions," chemical tests for common ions and radicals, formulas, common and chemical names for chemical compounds, etc. Among the definitions we find that a saturated solution "contains all the solute it can hold at the given temperature and pressure" and that a suspension is a "mixture of a solid and a liquid in which the solid particles settle out on standing." We find also that an "emulsion is a 'suspension' of one liquid in another."

Pupils will probably find that this review will help them to pass examinations and many teachers will like it for this reason.

BARNARD S. BRONSON

Oxidation-Reduction Reactions in Inorganic Chemistry. ERIC R. JETTE, Ph.D., Assistant Professor of Chemistry, Washington Square College, New York University. The Century Company, New York, 1927. xvi + 152 pp. 10 figures. 12.5 × 19 cm. $1.10.

The author conceives the purpose of the book to be the presentation of "a comprehensive discussion of oxidation-reduction reactions for the student who has had enough training in chemistry to understand ordinary chemical terminology but who has not had a course in physical chemistry." To this end the author believes two methods, the "valence change" and the "ion-electron" methods to be necessary. The basis for each of these methods is given; and numerous examples, which illustrate the effect of the conditions maintained during the reactions, are discussed. The preface statement indicates that the book is designed for students in courses more advanced than the usual first-year college course; and familiarity with the equilibrium principle and the theory of electrolytic dissociation is presupposed.

The "valence change" method, developed in the first part of the book, presents no new materials; but gives the author's scheme for representing the derivation of equations by this method, which he considers applicable only to non-ionic reactions, such as those between gases and solids at high temperatures. It may be noted that the form given here is somewhat less simple than some of the other schemes which have appeared in the literature from time to time.

The major portion of the book is devoted to a discussion of the "ion-electron" method. "The basis of the method is found in the fact that practically all of these reactions can be carried out so as to secure an electric current from them." According to this method, partial equations are written for the oxidizing agent and for the reducing agent, showing in ionic form the gain and loss of electrons for each. The final ionic equation is balanced by equalizing the numbers of electrons concerned. The balancing of a typical equation, represented on pages 38 and 39, requires six steps for securing the ionic equation (seven if a molecular equation is desired). The applicability of this method in balancing equations for reactions involving hydrogen peroxide, sodium thiosulfate, thiocyanates, and other less commonly used substances, in addition to the common oxidizing and reducing agents, is pointed out.

The discussion of atomic structure, valence, and the theoretical aspects of the subject including the effect of attendant conditions should be valuable for the students in the field for which the book is intended.

The method of balancing equations,

while theoretically sound, is more cumbersome than some of the other methods which have been described in THIS JOURNAL, particularly for those users who prefer to express reactions in the form of molecular equations.

Certain inconsistencies are noted in that the author writes on page 31: "Unless we are able to state (and prove such statements) that an atom has lost seven electrons, we cannot state that the valence of that atom is +7." Nevertheless, in the work on pages 13 and 18 such assumptions have been made and the table on page 11 contains additional examples of this. One notes also a few careless expressions such as that on page 76: "The various states of oxidation given on page 67 can react with each other."

In the opinion of the reviewer, this monograph will not prove valuable for use in elementary courses in chemistry. The student in such courses cannot understand the logical development of the method at the time he begins to encounter oxidation-reduction reactions. The method itself is somewhat more cumbersome than others which involve the application of electronic steps. Many teachers will object to the exclusive use of ionic instead of molecular equations, particularly during the early stages of the work. If the method presented by Professor Jette is to be followed, it would appear to be necessary for the student first to learn some other method of handling the equations for common oxidation-reduction reactions; and then in his more advanced work to take up such phases of this method as may prove useful for considering the less common cases.

STUART R. BRINKLEY

New Type Questions in Chemistry. CHARLES G. COOK, Ph.D., Globe Book Co., New York, 1927. First edition. vi + 91 pp. 12.5 × 19 cm. Cloth, 60 cents.

This little book sets as its task to "make chemistry teaching more efficient and more interesting."

Types of tests used are:

"The old type . . , true-false . . , completion . . , evidence . . , statements for correction, and home tests."

Advantages of use of new-type tests are that "a greater number of topics may be covered in short tests" and "the answer paper may be corrected rapidly."

The book contains in the neighborhood of a thousand requirements covering individual requirements for eleven elements, requirements for fifteen others grouped after the periodic arrangement with special test groups upon a number of typical compounds such as water, hydrogen peroxide, hydrochloric acid, oxides of sulfur, etc. Theories, atoms, molecules, nomenclature, Avogadro's hypothesis, molecular weights and formulas, electrolytic dissociation theory; reversible reactions and the periodic law come in also for individual test requirements. Five specimen sheets of examinations, presumably from the Regents' sets, though not so stated, are given as an appendix "to familiarize the student with the type of questions he is expected to be able to answer."

Criticisms that are likely to come to the booklet are: too much space devoted to equations; not enough numerical problems; acids, bases, and salts not recognized; oxidation and reduction not treated separately, and an undue use of true-false requirements.

The book will undoubtedly be welcomed by a host of teachers, especially those teaching in high schools. While it is hardly the last word in the field of testing it is a creditable pioneer offering from the hands of a teacher of experience. This is undoubtedly a field which the future will see more fully cultivated.

B. CLIFFORD HENDRICKS

Essays on the Art and Principles of Chemistry. HENRY E. ARMSTRONG. The Macmillan Company, New York, 1927. xxxi + 276 pp. 22 × 15 cm. $4.50.

The essays in this volume are entitled: "The Art and Principles of Chemistry;" "A Dream of Fair Hydrone;" "The Thirst of Salted Water;" "The Corrosion of Iron and Other Metals;" "First Messel Memorial Lecture;" "The Origin of Osmotic Effects;" "Electrolytic Conduction." The first essay was written for the thirteenth edition of the *Encyclopædia Britannica* and the others for Mr. Armstrong's amusement.

The book is dedicated to "my seven grandsons and my seven granddaughters, hoping that one or more may develop the individuality to think for him or herself and not to bow the knee to authority." Mr. Armstrong is apparently a scientific Fundamentalist who advocates independence of thought and a revolt against authority. This sounds like a contradiction in terms; but what Mr. Armstrong means is that he wishes people to break away from the existing beliefs—which might be a good thing—and to adopt his—which would certainly be unfortunate. Mr. Armstrong preaches tolerance; but is hopelessly intolerant of all views except his own.

Mr. Armstrong is now and always has been an enthusiastic opponent of the theory of electrolytic dissociation. In the forty-odd years that he has been campaigning against it, he has not succeeded in developing any substitute theory which made any pretense of being quantitative. Since one cannot overthrow a theory with facts—even if one has the facts—Mr. Armstrong has less of a following now than he had in the beginning, when the Theorem of Le Chatelier was working in his favor, and when the attempt to overthrow the existing scientific equilibrium produced at the time a mental reaction against the new doctrine.

The sad part about all this is that Mr. Armstrong has not been entirely wrong. He has insisted that water is a polymerized liquid and that this should be kept in mind when discussing aqueous solutions. He is, of course, quite right about this; but, unfortunately, he has never been able to make any effective use of this idea and consequently his advocacy of it has been harmful rather than helpful.

This book is well worth reading for its psychological bearing. The reviewer can recommend it to advanced students in chemistry.

WILDER D. BANCROFT

The Chemical Elements and Their Compounds. J. A. V. BUTLER, D.Sc., (Birmingham), Lecturer in Chemistry in the University of Edinburgh. Macmillan and Company, Ltd., London and New York, 1927. First edition. xi + 200 pp. Number of figures, 34 in text + 9 in appendix. 8.5 × 12.5 cm. $2.00.

"The advances of the last decade have revealed the chemical elements as members of a strikingly simple system, and consequently inorganic chemistry need no longer suffer from the reproach which has so often been brought against it, that it consists of great numbers of uncoördinated facts with no unifying theory. The main features of the beautiful structure which has emerged from twentieth-century physics stand out clear and, in the main, free from hypothesis, forming a rational basis for the study of the chemical elements and their compounds.

"The author believes that the time has come to incorporate the new standpoints into the general body of chemical studies—most of the matter in Chapters I to VI has been put before students in their second year (of chemistry study).

"The author has endeavored to present the newer knowledge and points of view in their proper historical perspective. Chemical theory is not a completed structure—every stage has grown out of that which preceded it."

The book "is intended to be used in conjunction with an adequate descriptive textbook. The references....are in no sense exhaustive. They are intended to guide the further reading of the student, and to draw his attention to classic papers...."

The treatment is not mathematical, nor, on the other hand, is it "popular."

At the same time the experimental basis of the theories is given as exactly as possible.

The first two chapters cover the "Atomic Theory" and the "Theory of Electrolytic Dissociation," mainly in historical fashion. The new theory of "complete ionization" is not mentioned.

Chapter III, "The Election in Chemical Combination," describes such matters as the measurement of the electronic charge, polarity of valency, and oxidation-reduction changes.

Chapter IV, "Complex Compounds" includes much of Werner's theory, while Chapter V describes the "Periodic Table."

Chapter VI covers "The Constitution of the Atom," but much more of the same sort of material comes in Chapter VII, "The Periodic System of the Elements," Chapter VIII, "Structure and Properties of Certain Compounds" and Chapter IX, "The Radioactive Elements."

Chapter X covers "Atomic Weights and Isotopes."

The reviewer considers this little book a distinct addition to the literature of chemistry. The treatment is accurate, although not in all cases quite up to date; moreover, it leaves the reader with the feeling that he would like to know more of the subject.

Perhaps the title of the book is, for American readers, a little misleading. As the review shows, it is really a book on the "*Structure* of the Chemical Elements and Their Compounds."

W. H. CHAPIN

Social Intelligence More Useful Than Brains. Success or failure in life is very largely determined by the ability to get along with others, and in no trait do people differ more than in this ability, Dr. Fred A. Moss, of George Washington University, declared recently in reporting latest experiments in social intelligence before the American Psychological Association, Columbus, Ohio.

A test of social intelligence, devised by Dr. Moss, has been given to several thousand individuals. The highest possible score on the test is 160 points, and the highest record so far made is 145, scored by a college boy who expects to go into politics.

Executives who took the test scored the highest as a group in this ability to react intelligently to social situations, Dr. Moss found. The median, or middle, score for the group of executives was 117. Teachers made 112, salesmen 107, clerks and stenographers 95, sales clerks 81, nurses 78, and low-grade industrial workers 65.

Dr. Moss's test measures the individual's judgment in meeting social situations, his ability to appreciate the mental state back of spoken words and back of facial expressions, his understanding of human motives, and his ability to remember names and recognize faces.

The scores indicate that ability to get along with other people may be developed, unlike mental ability, which is generally believed to be unchangeable. High-school students scored only 83 on the test, while college freshmen made 104 points, upper classmen 114, and graduates 116.

Although not designed particularly for that purpose, the test seems to be useful in predicting school success, Dr. Moss said. In many subjects the teacher grades his students largely according to his personal estimate of their knowledge and ability, and in these subjects it is often better to know the instructor and his pet interests than to know the general subject-matter of the course, he pointed out. The student who has a keen social understanding, therefore, is likely to make better grades than the one who blunders in understanding and dealing with other people.—*Science Service*